# NAVAL POSTGRADUATE SCHOOL
# Monterey, California

# THESIS

**REAL-TIME ENGAGEMENT AREA DEVELOPMENT PROGRAM (READ-Pro)**

by

Joseph Burger

June 2002

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**13. ABSTRACT *(maximum 200 words)***

The Real-Time Engagement Area Development Program (READ-Pro) is a PC-based prototype system which provides company-level commanders with real-time operational analysis tools to develop engagement areas (EA) for direct fire (DF) systems. READ-Pro automates and streamlines the current manual system. READ-Pro significantly enhances the evaluation of a defense by presenting the commander with a visual display of the coverage and a quantitative measure of its fragility. READ-Pro also supports the rapid evolution to a better defense by providing visualization of the coverage and a quantitative evaluation at each step in the engagement area development process.

READ-Pro creates a layered environment consisting of digital terrain elevation data (DTED©), a standard military map, overlays, and imagery. A ModSAF line-of-sight (MLOS) algorithm, based on the ModSAF terrain model, calculates measures of effectiveness related to line-of-sight coverage. READ-Pro also includes a Monte-Carlo Simulation to quantify the fragility of a defense.

READ-Pro incorporates the tactics, techniques and procedures used in today's Army, namely the troop-leading procedures and 7 steps of engagement area development. Thus, READ-Pro can also be used to train leaders on the fundamentals associated with engagement area development.

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# REAL-TIME ENGAGEMENT AREA DEVELOPMENT PROGRAM (READ-Pro)

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Submitted in partial fulfillment of the
requirements for the degree of

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## SOFTWARE AVAILABILITY AND DISCLAIMER

An electronic version of this thesis and the Java code for READ-Pro are both available via the internet at http://diana.or.navy.mil.

The reader is cautioned that the computer programs developed in this research may not have been exercised for all cases of interest. While every effort has been made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

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# EXECUTIVE SUMMARY

The Real-Time Engagement Area Development Program (READ-Pro) is a PC-based prototype which provides company-level commanders with real-time operational analysis tools to develop engagement areas (EA) for direct fire (DF) systems. It provides the commander a powerful tool that links him to information at all levels and assists him in managing the information. Unlike the current manual method of engagement area development, READ-Pro enables a commander to quickly conduct mission analysis of multiple courses of actions. Furthermore, the analysis conducted is more accurate than using a paper map.

READ-Pro creates a layered environment consisting of digital terrain elevation data (DTED©), a standard military map, overlays, and imagery. It uses a terrain model that is compatible with any level of DTED (Level 1 through 5). READ-Pro implements a ModSAF line-of-sight algorithm, based on the ModSAF terrain model, to calculate two main measures of effectiveness (MOE). The first is the percentage of the engagement area covered by all platforms placed on the battlefield. The second uses a Monte-Carlo Simulation to quantify the fragility of a defense. A predetermined percentage of the total force is randomly destroyed and the EA coverage from the remaining vehicles is calculated. This procedure is repeated over many iterations yielding the average percentage of EA coverage that is the second main MOE.

In military operations, one of the end products of developing an engagement area is the direct fire control matrix (DFCM). The commander tasks subordinate units to cover various areas with direct fire or line of sight. READ-Pro automates the construction of the DFCM and calculates the percent coverage of the assigned areas by the corresponding subordinate unit. This gives the commander a coverage metric to determine if the unit can achieve its assigned task.

READ-Pro incorporates the tactics, techniques, and procedures used in today's Army, namely the troop-leading procedures and 7 steps of engagement area development. Thus, READ-Pro can also be used to train leaders on the fundamentals associated with engagement area development.

Chapter IV demonstrates the potential impact of READ-Pro. An actual defense conducted at the National Training Center (NTC) by an armor battalion is entered into READ-Pro. The analysis from READ-Pro suggests many observations similar to those made by the evaluation team at NTC. READ-Pro provides visual and quantitative feedback which highlights the aspects of the fundamentally flawed plan. Using line of sight, range circles and various measures of effectives, the commander can judge the quality of a given defense. If the commander deems it necessary, READ-Pro enables the commander to quickly evolve a quantifiably better defense by comparing various courses of action.

READ-Pro fuses current military procedures with new computer and analytical technologies. By using the decision support tool READ-Pro, the company-level commander can quickly make quantifiably better engagement areas.

# I. INTRODUCTION

*“The art of war is simple enough. Find out where your enemy is. Get at him as soon as you can. Strike him as hard as you can, and keep moving.”*
**Ulysses S. Grant**

## A. BACKGROUND

Company level commanders have been using the same basic techniques to analyze terrain and conduct mission analysis for thousands of years. Paper maps, pens and walking the physical terrain were used by the ancient Greeks just as they are used by soldiers in today’s Army of the twenty-first century. With all of the advancements in technology and intelligence gathering, the company level commander should have a larger set of decision support tools at his disposal.

A common trend in modern warfare is increased tempo and speed of information. In order for commanders to stay one step ahead of their enemies, they must minimize their decision-making time while simultaneously maximizing the quality of those decisions. The Real-time Engagement Area Development Program demonstrates the benefits of using real-time operational analytical tools to develop engagement areas for direct fire systems. It automates and streamlines the current manual system, and provides immediate feedback on the quality of the engagement area based on various criteria.

READ-Pro provides lower level commanders real-time analytical tools to assist them in assessing the

effectiveness of an engagement area. It can also be used to train leaders on the tasks associated with EA development. It is a platform independent program that runs on any PC or laptop computer for use during combat operations and in the training environment.

READ-Pro also generates a XML compatible scenario that is exportable to a simulation such as the Army and Marine Corps' Combat XXI [Combat XXI, 2002].

## B. SCOPE OF THESIS

The research focuses on the lower level decision-maker, i.e. the company commander and below. In the military, the company commander is the highest level decision-maker without a staff that must conduct mission analysis and course of action development. READ-Pro is a technological demonstration of how real-time analytical tools can assist the company commander in making a better plan faster. Anything that can buy a commander more time to implement his plan is valuable. READ-Pro is a decision aid that supports the decision-maker but does not attempt to replace him. It provides real-time feedback that assists the decision-maker and enables him to quickly develop multiple courses of action.

## C. PROBLEM DEFINIITION

Anyone can be trained to shoot a weapon, but training someone where to place that weapon so that it can bring to bear shock and violence at the decisive point is much more complicated. Bringing destructive fire upon the enemy is one of the primary responsibilities of a company level

commander.  In the defense, for example, this equates to developing an engagement area.

The process begins when the higher commander, such as the battalion commander (BC), issues the battalion operations order to the company commander.  The order provides the company commander the following information: enemy situation, friendly situation, brigade and battalion mission statements, BC's intent, battalion's scheme of maneuver, company tasks, logistical support, command structur, and communications associated with the operation. The BC divides up the battalion’s sector of responsibility down to his companies and provides friendly forces graphic control measures in order to control maneuver between companies (See Figure 1).  With this information, the battalion can mass its fires, both direct and indirect, to obtain the greatest effect.  Once a company commander has his sector of responsibility and his higher commander’s intent, the company commander must conduct mission analysis and troop-leading procedures and array his forces accordingly to accomplish the company's mission.

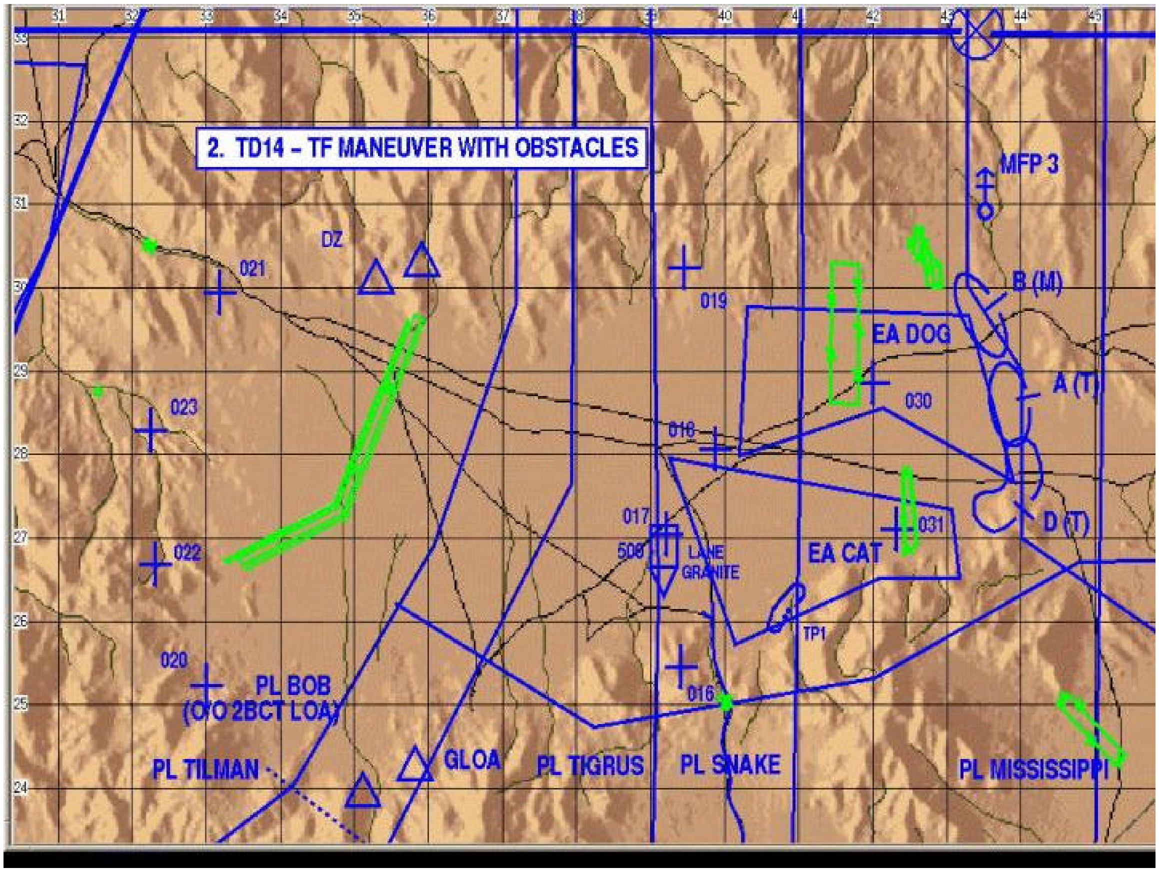



Figure 1. Friendly Forces Graphics (From: Actual Graphics from a Unit at the National Training Center).

The company commander (CC), as the decision-maker, must decide how to array his forces to defend his engagement area. In many cases, due to a variety of constraints, the commander must develop the company plan with little input from his subordinates. Most of the company subordinates are not in a position to influence the commander's decision until after the plan is being executed. Changes such as repositioning fighting positions or obstacles recommended by his subordinates may drastically affect the commander’s original plan.

The military decision-making process at the lower level follows a 7 step process called the troop-leading procedures (TLPs) [*FM 17-15,* 1996].

- TLP Step 1: Receive and analyze the mission (battalion operations order).
- TLP Step 2: Issue a warning order to subordinates.
- TLP Step 3: Make a tentative plan.
- TLP Step 4: Initiate movement.
- TLP Step 5: Conduct reconnaissance and coordination.
- TLP Step 6: Complete the plan.
- TLP Step 7: Supervise and refine the plan.

The 7 TLPs are not necessarily followed sequentially. Different missions may require the commander to change the order or, more importantly, do several steps simultaneously. In the defense, TLP steps 1,2,3 and 5 are further broken down into 7 additional steps called engagement area development [*FM 71-1,* 1998][McClelland, 1997]. Once the CC has his designated engagement area and available resources, he uses the following steps:

- EA Step 1: Visualize how the enemy will/might attack into EA.
- EA Step 2: Select where and determine how to kill the enemy.
- EA Step 3*: Position direct fire systems to kill the enemy.
- EA Step 4*: Position and integrate obstacles to support direct fire systems.

- EA Step 5*: Plan indirect fires to support direct fires and obstacles.
- EA Step 6: Complete the plan, drive EA, select/prepare final positions, site obstacles and triggers
- EA Step 7: Rehearse.

*May be done concurrently

Some of the information for EA development is provided in the battalion operations order, but it does not apply at each specific company level. Further refinement is required in order to provide the company elements specific instructions. The 7 TLPs and 7 EA development steps capture the majority of the tasks the company commander must accomplish. The Center for Army Lessons Learned (CALL) has repeatedly observed that units spend too much time planning (trying to accomplish all of the subtasks) and not enough time implementing their defense. This results in an incomplete execution of the company plan and more often than not, a failed mission. There are many factors that contribute to a poor plan, both in and out of the control of the commander. The purpose of READ-Pro is to influence the factors that are in the control of the company commander. READ-Pro enables a commander to do more of the tasks, in less time and with better quality, thus reducing the number of refinements done during execution.

## D. COMPANY COMMANDER’S RESPONSIBILITIES

In the defense, time is traditionally the biggest constraint on the company commander [*FM 100-5*, 1993]. As the commander develops his plan, he combines available resources with his mission, conducts mini wargames and ultimately determines where to destroy the enemy in the

engagement area. He positions his assets to ensure observation and direct fire throughout his sector. Once he knows where he wants to place his assets, the remaining time is dedicated to digging fighting positions, emplacing obstacles to shape the engagement area and rehearsing the fight. Increasing the amount of time the unit spends emplacing the defense is critical. The textbook solution in time management is the 1/3 - 2/3 rule. Of the time allocated between receiving the order and execution, no more than 1/3 of available time should be spent on developing the plan and the remaining time, at least 2/3, should be spent on executing the plan. Good commanders do things simultaneously versus sequentially to give the unit as much time as possible to execute. Many things, such as moving to the assigned area and the prepositioning of needed obstacle material in the general area are not dependent on a finalized plan.

A mission usually fails because a commander develops a good plan but takes too long planning or he implements a poorly devised plan. Many constraints affect the commander’s decision cycle. First of all, the company commander's battalion commander may not give him enough time to do all the traditional tasks associated with emplacing a deliberate defense, resulting in a hasty defense. Many other conditions affect the planning/development process such as the following:

- At night versus during the day
- Engagement area occupied by enemy, therefore cannot drive EA

- Expertise or experience level of subordinates providing feedback
- Weather
- Terrain
- Status of unit in terms of supply and maintenance
- Incomplete information from higher headquarters
- Changes from higher headquarters
- Constraints from higher headquarters
- Requirements from higher headquarters
- Morale
- Sleep deprivation

According to doctrine, a company commander plans two levels down (company -> platoon (1 level) -> vehicle (2 levels)) [*FM 17-123,* 1992]. Although a vehicle commander refines his actual location once on the ground, the company commander initially places all vehicles. At the end of the planning phase, he provides the unit with two main products. The first is the operations overlay, a graphical representation of how the unit's assets are arrayed on the battle field and friendly graphic control measures used to orchestrate the battle (See Figure 2). The second is the direct fire control matrix. (See Figure 3).

Figure 2. Company Level Graphics (Actual Scale).

Current military practice uses laminated paper maps and acetate overlays. Availability, dissemination, and accuracy of maps are often an issue. It is not uncommon for people in the same unit to operate from different versions of the same map, with one map missing critical information such as climatic variations or no-fire zones. Additionally, doing analysis on a 1:50,000 map is very challenging. The scale of the map is too large to do micro planning. A standard map only represents 20 meter changes in elevation. In relation to direct fire combat, this could equate to two vehicles 20 meters apart but unable to see each other due to a 18 meter high ridge. At the small unit tactics level, this is the difference between success

and failure. Figure 2 is a typical overlay of actual scale. According to the scale, the tanks are 200 by 200 meters in dimension. This is obviously a gross exaggeration and an approximate location at best. The locations of the vehicles give subordinates approximate locations that must be further developed once the vehicle occupies the terrain. This is satisfactory unless once on the actual terrain, vehicle locations are so impractical that the CC's plan must be drastically altered. For example, if a commander designates a particular platoon as the main effort he will normally commit scarce resources to that platoon, i.e. bulldozer time to dig fighting positions. Based on the situation, he must commit this resource before he can occupy the terrain. If the commander then finds out that his main effort can only see a small portion of the engagement area due to unforeseen terrain undulations, the commander has wasted a valuable asset.

As mentioned earlier, the second main product from a company commander to his subordinates is the direct fire (DF) control matrix (See Figure 3) [Miller and Averna, 1993][Miller and Averna, 1994]. The DF control matrix explicitly states what each subordinate unit does during the mission. It breaks down the engagement into phases. A trigger signifies the start of each phase. For each phase, each subordinate unit's responsibility is broken down into 5 categories.

| Direct Fire Control Matrix | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| Trigger | | Unit | | Unit | | Unit |
| Enemy crosses | | Red | | White | | Blue |
| PL Far | 1 | 120mm | 1 | TOW | 1 | 25mm |
| | 2 | destroy | 2 | destroy | 2 | destroy |
| | 3 | tanks | 3 | tanks | 3 | PC |
| | 4 | cross | 4 | frontal | 4 | depth |
| | 5 | A1 | 5 | A1 | 5 | B2 |
| | | | | | | |
| Enemy crosses | | Red | | White | | Blue |
| PL Near | 1 | 120mm | 1 | 25mm | 1 | 25mm |
| | 2 | destroy | 2 | destroy | 2 | destroy |
| | 3 | tanks | 3 | PC | 3 | PC |
| | 4 | cross | 4 | frontal | 4 | depth |
| | 5 | A1 | 5 | B1 | 5 | B2 |

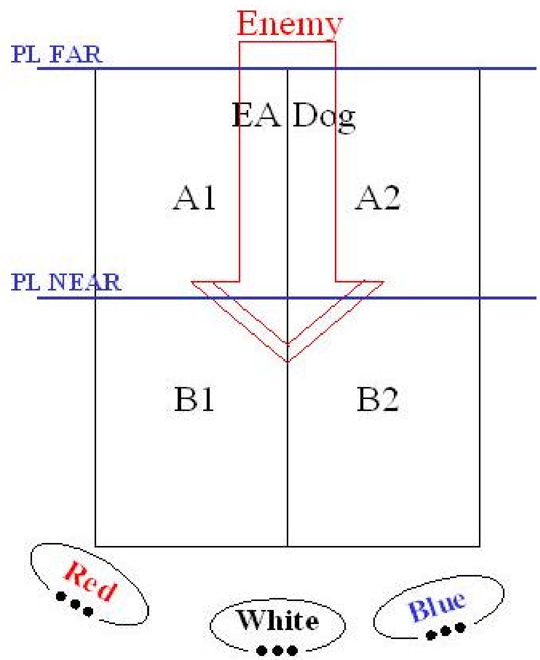



Figure 3. Direct Fire Control Matrix.

| | |
|---|---|
| 1 | Weapon to be used by subordinate |
| 2 | Direct fire intent (destroy, suppress, neutralize, fix, block) |
| 3 | Engagement priority (tanks, personnel carriers, infantry) |
| 4 | Fire techniques (frontal, depth, cross) |
| 5 | Fire control measure (quadrant A1, A2, B1, B2) |

Table 1. Each Subordinate Unit's Responsibility Broken Down into 5 Categories.

Using these 5 categories, the commander can convey his DF mission and intent to his subordinates. The direct fire

matrix gives each subordinate the who, what, where, when, why, and how for each phase of the battle.

## E. REAL-TIME ENGAGEMENT AREA DEVELOPMENT PROGRAM (READ-PRO)

Lower level commanders (battalion and below) normally do not have access to many of the advancements in technology and intelligence gathering that is available to higher-level commanders (brigade and above). READ-Pro bridges some of these gaps. It is a computer program decision support tool for company-level commanders, which assists the commander in developing an engagement area. The program enables the commander to access and benefit from all available digital information from higher and lower units. It provides real-time feedback on the feasibility of various tasks assigned by the commander to his subordinates. The commander can then alter or refine his plan based on this feedback. READ-Pro also serves as a medium for the commander to generate the traditional products required to execute a plan, specifically: maneuver graphics, obstacle overlays, indirect fire overlays, recon and surveillance overlays, and the direct fire control matrices. It is an easy to use program that runs on any personal computer that has installed the free download to run Java programs. Using the existing network hierarchy and hardware affiliated with current systems, READ-Pro links all users to a common perception of the battlefield.

READ-Pro creates a layered environment consisting of digital elevation data (DTED©), a standard military map, overlays and imagery (See Figure 4).

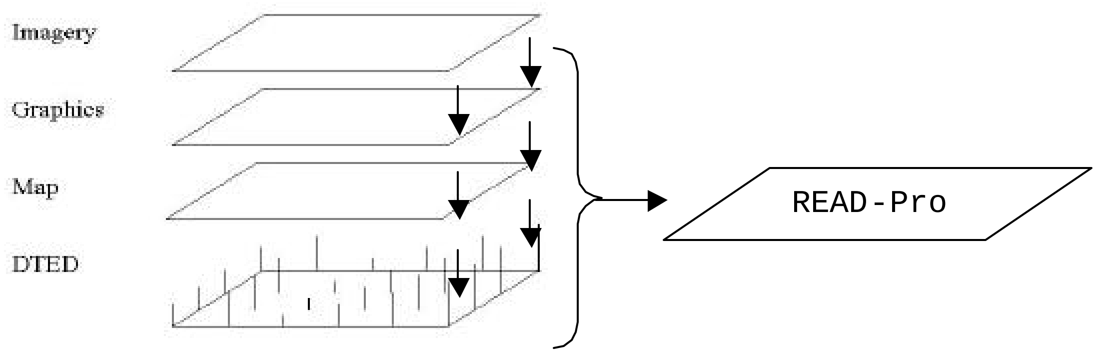



Figure 4. READ-Pro Environment.

Together, these layers allow the commander to get a visual representation of the line-of-sight (LOS) range fans from all emplaced vehicles or platforms. This line-of-sight information is used to calculate the measures of effectiveness in terms of percent coverage of assigned area. By selecting different locations and displaying the corresponding LOS fan, the commander can explore his area of operations faster and with thoroughness comparable to being on the ground. The purpose of READ-Pro is not to replace a leader's recon [*FM 71-123*, 1992], rather to supplement it and provide a suitable alternative if it is not feasible to actually conduct a physical reconnaissance. Many times occupying your area is not feasible due to time or visibility constraints or because the enemy still occupies the same terrain.

READ-Pro also serves as an information fusion tool. All of the information that is available through READ-Pro

would be overwhelming and impractical to physically possess. This program allows the commander to filter out some information, disregard other information and merge still other information with a simple manipulation of a computer mouse, touch pad or by voice command. Using color schemes and abstractions of the measures of effectiveness that are not distracting, the user absorbs information that they would normally have to ask for, for example, what type of indirect fire assets can service a particular target.

## F. BENEFITS OF READ-PRO

READ-Pro provides the commander with tools to facilitate many aspects of the TLPs and 7 step EA development process. First of all, all digital products produced by the higher command, such as satellite images, higher operational overlays, modified combined obstacle overlays, enemy situational templates, etc., can easily be accessed with READ-Pro (See Figure 5). The commander has the ability to fade and interchange overlays without the clumsiness associated with maps and overlays. No one wastes time copying or generating any products. Human error due to battlefield conditions and the transfer of this information is drastically reduced (no one needs to hand copy graphics or post overlays). In addition, all information can be transmitted to higher or lower commands as changes occur. This allows for simultaneous effort since the plan does not have to be complete before information is disseminated.

The commander can also develop the direct fire plan overlay and matrix using READ-Pro (See Figure 6). By using

READ-Pro versus the traditional method, the commanders' orders to platoons to engage into different areas is quality controlled by a line-of-sight algorithm which provides feedback to the commander on the feasibility and practicality of the orders.

Using READ-Pro saves time in the planning phase and makes plans more thorough and accurate than they otherwise might be by using only a paper map. This, in turn, results in more time for the execution phase.

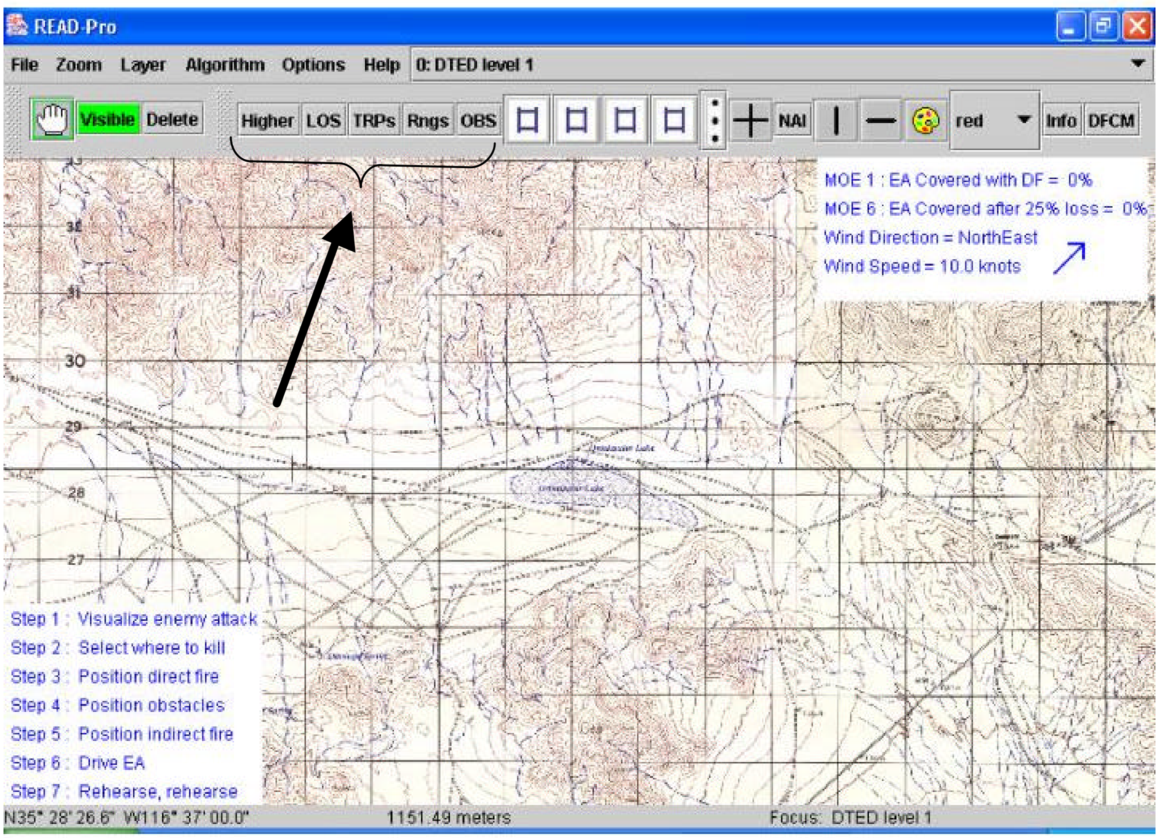
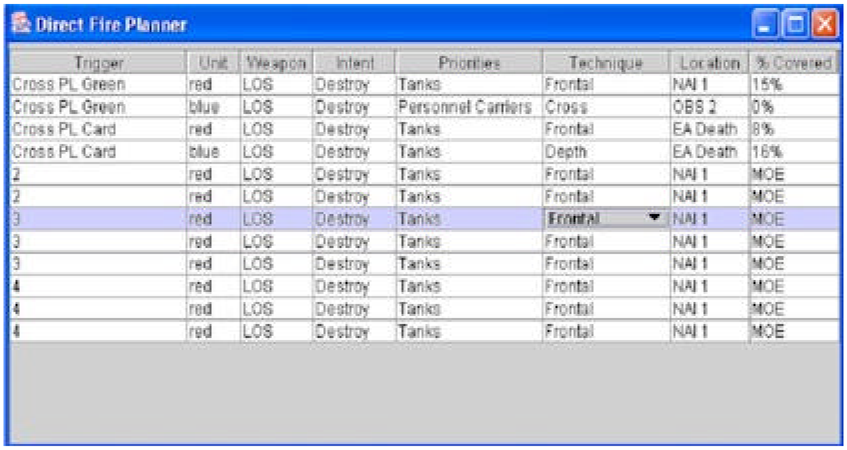



Figure 5. Toggles for Various Overlays.


Direct Fire Planner

| Trigger | Unit | Weapon | Intent | Priorities | Technique | Location | % Covered |
|---|---|---|---|---|---|---|---|
| Cross PL Green | red | LOS | Destroy | Tanks | Frontal | NAI 1 | 15% |
| Cross PL Green | blue | LOS | Destroy | Personnel Carriers | Cross | OBS 2 | 0% |
| Cross PL Card | red | LOS | Destroy | Tanks | Frontal | EA Death | 8% |
| Cross PL Card | blue | LOS | Destroy | Tanks | Depth | EA Death | 16% |
| 2 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 2 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |

Figure 6. Direct Fire Control Matrix.

## G. MEASURES OF EFFECTIVENESS

Using line of sight algorithms and six measures of effectives, READ-Pro provides a commander with an analytical tool to evaluate his defense. It also provides real-time feedback on the feasibility of various tasks the commander assigns to his subordinate units. There are six (6) measures of effectiveness:

(1) Percentage of engagement area covered by line-of-sight (See Figure 7)

(2) Percentage of engagement area covered by direct fire systems

(3) Percentage of area of operations covered by line-of-sight

(4) Percentage of area of operations covered by direct fire systems

(5) Percentage of targeted area of interest covered by direct fire systems (See Figure 8)

(6) Amount of overlap/redundancy in the defense (See Figure 7)

MOEs 1, 2, 5 and 6 are fully implemented in READ-Pro, and the remainder are partially implemented. MOEs 1 through 5 are based on a line-of-sight algorithm.

MOE 6 is calculated using a Monte-Carlo Simulation. The simulation determines how well the defense remains intact, with respect to LOS coverage, after a certain percentage of its vehicles are destroyed. The commander determines how many vehicles he needs to have in order to continue to fight, for example, 75 percent of his starting force. This is the threshold level of success. A random 25 percent of the total vehicles emplaced by the commander is then removed and the percent of EA covered by line-of-sight is recalculated to determine new percent coverage. Multiple iterations are run (i.e. 10,000), and the average percentage of coverage calculated. This new value, MOE 6, gives the approximate percentage of coverage of 75% of the initial force. Since a redundant defense is not heavily reliant on a few vehicles, MOE 6, for a good defense, should not be drastically lower than MOE 1.

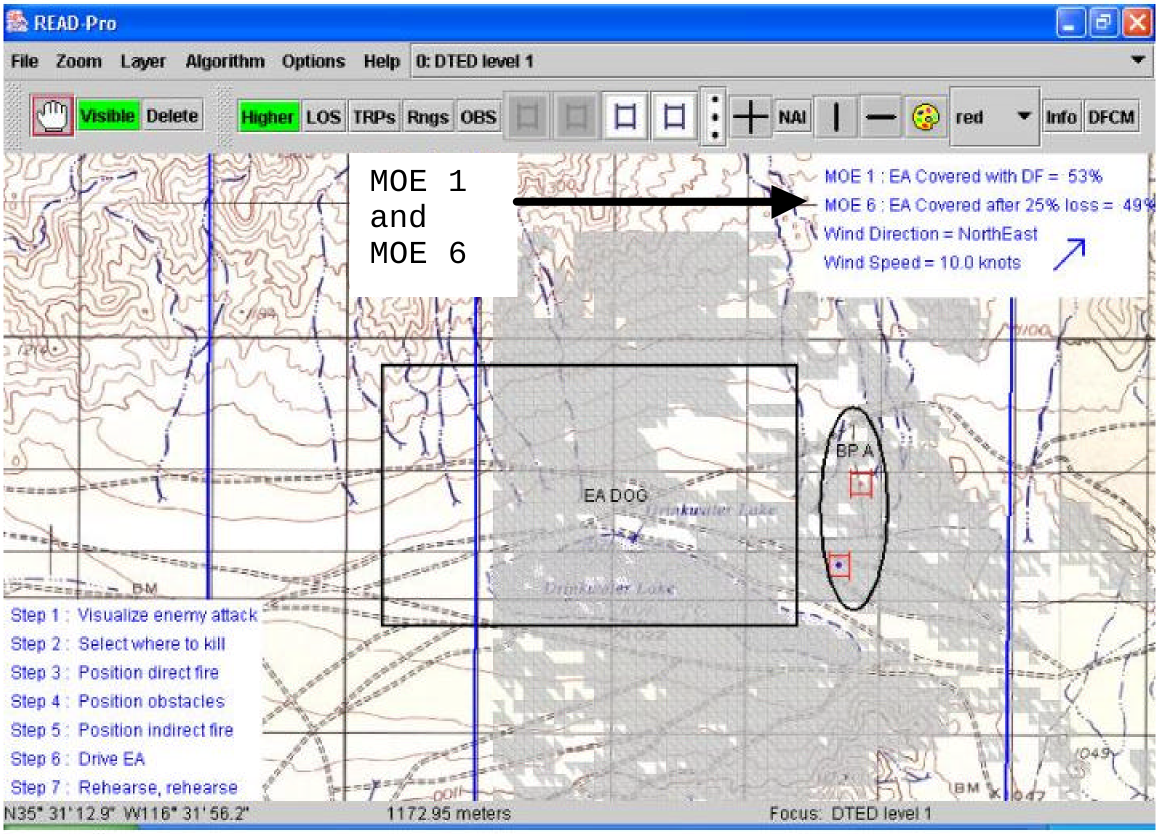
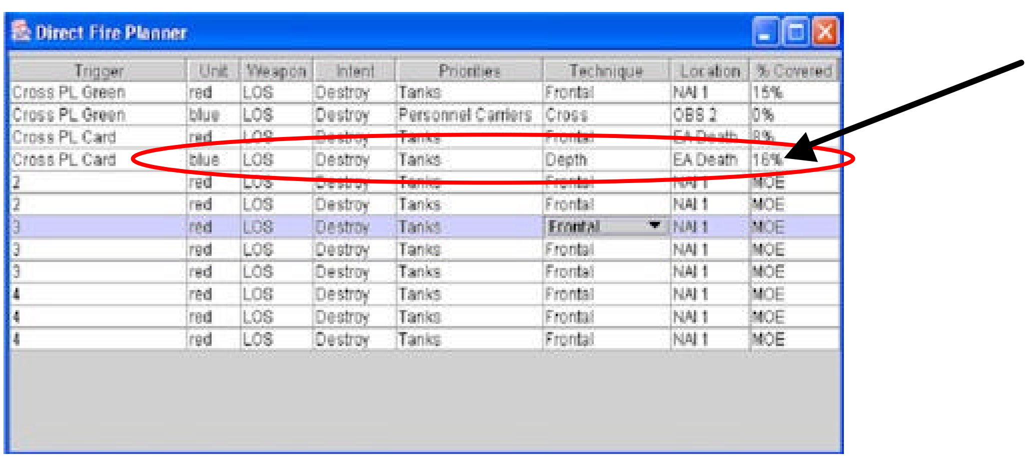



Figure 7. EA MOE Screen Shot. Gray area is what can be seen.



Direct Fire Planner

| Trigger | Unit | Weapon | Intent | Priorities | Technique | Location | % Covered |
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| Cross PL Card | red | LOS | Destroy | Tanks | Frontal | EA Death | 8% |
| Cross PL Card | blue | LOS | Destroy | Tanks | Depth | EA Death | 16% |
| 2 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 2 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | red | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |

Figure 8. READ-Pro Automated Direct Fire Control Matrix.

The automated direct fire control matrix provides the commander with feedback on the ability of the assigned unit to accomplish the specified task (See Figure 8). This is broken down by the percent of vehicles that can see into the selected area and the amount of the area covered by the specified unit. This is a similar calculation as MOE 1. The commander can task a single unit (color) or all units to cover a particular area (location). Figure 8 shows that Blue can only cover 16% of EA DEATH. With this information, the commander can decide if the coverage by Blue is enough to accomplish the assigned task or more resources are required.

## H. FUTURE APPLICATIONS

Research and technology have taken great strides in both terrain information and simulation. In the very near future, DTED 2,3,4, and 5 coupled with micro-terrain features (foliage) will be available. READ-Pro is compatible with both current and future terrain technology. Advances in technology such as flat rollable monitors will be available in the near future [Philips Research, 2002]. The commander will soon have an accurate virtual environment to plan his engagement area.

READ-Pro stores all scenario information using XML, this information could be exported to a simulation such as the Army’s Combat XXI [Combat XXI, 2002]. This scenario could then be simulated to get immediate feedback on the commander’s defense. READ-Pro demonstrates how the military advances in information management and

digitization can be brought in an effective and cost efficient manner to the company commander.

# II. BUILDING BLOCKS

## A. DIGITAL TERRAIN ELEVATION DATA (DTED©)

The National Imagery and Mapping Agency (NIMA) developed a standard digital dataset (Digital Terrain Elevation Data (DTED)) which is a uniform matrix of terrain elevation values which provides basic quantitative data for systems and applications that require terrain elevation, slope, and/or surface roughness information. The DTED data can be interpreted either as elevation poles (See Figure 9) or as grid "cells" of known information. A grid cell is a relative area surrounding the elevation pole of a known elevation, namely the value at the center of the grid.

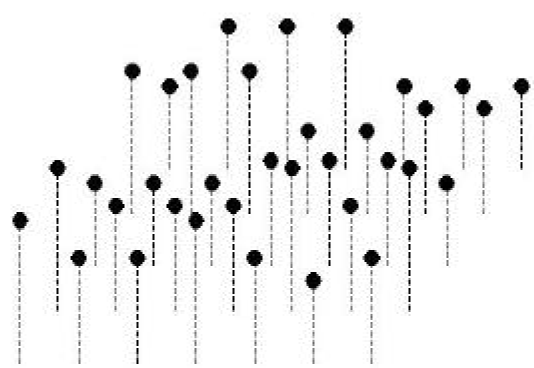

Figure 9. DTED Elevation Poles.

There are six levels of DTED, 0 through 5. DTED Level 0 is the Internet version of DTED Level 1. Each level

represents a different resolution of data, determined by the post (DTED poles) spacing measured in varying degrees. The higher the level, the smaller the spacing between poles resulting in a higher resolution of data and a better representation of the terrain.

DTED Level 1 is approximately equivalent to the contour information on a 1:250,000-scale map. The post spacings are every three (3) arc seconds (approximately 100 meters). Virtually the entire surface of the Earth has corresponding Level 1 DTED.

DTED Level 2 is approximately equivalent to the contour information on a 1:50,000-scale map, the common military map. The post spacings are one (1) arc second (approximately 30 meters). A 2001 space shuttle mission collected level 2 elevation data for 80 percent of the Earth’s land mass, however, conversion to DTED 2 is not yet complete.

DTED Level 3 (approximately 10 meter postings), DTED Level 4 (approximately 3 meter postings), and DTED Level 5 (approximately 1 meter postings) are available for only small areas of the world.

The main difference in DTED levels, besides the accuracy, is the storage requirements to support them [See Table 2]. DTED 5 has approximately a thousand times more data points (506,250,000 points) than DTED 2 (810,000 points). READ-Pro can utilize both higher resolution DTED, such as DTED 5, and the corresponding higher resolution maps. As computer speed and RAM increases, higher DTED levels will become more practical.

| DTED Level | Post Spacing | Data Points | Megabytes |
|---|---|---|---|
| 1 | ~ 100 meters | 1,442,401 | 5 |
| 2 | ~ 30 meters | 12,967,201 | 54 |
| 3 | ~ 10 meters | 144,024,001 | 583 |
| 4 | ~ 3 meters | 1,296,072,001 | 6,297 |
| 5 | ~ 1 meter | 11,660,000,000 | 68,001 |

Table 2. Data for 1 Degree by 1 Degree Area (60 Square Nautical Miles at the Equator).

## B. MODSAF TERRAIN MODEL

Since there is only elevation data at the data poles, DTED data alone provides a very crude terrain model. In order to smooth out the model, some form of interpolation must be conducted between DTED poles. There are many different approaches to this problem. The technique selected for READ-Pro is referred to as the ModSAF terrain model. This terrain model first conducts a two-way interpolation between any two adjacent DTED poles (north to south and east to west) (See Figure 10). This interpolation connects all adjacent DTED poles with a line of corresponding elevations, forming a square with DTED poles at the corners. An additional two-way interpolation between the upper left and lower right elevation poles of each DTED square is conducted along a line joining the two corners (See Figure 10). Elevation along each of the line segments is now available. If a point is not on a line segment, a three-way elevation interpolation amongst the

three DTED poles that surround the location of the point is done.

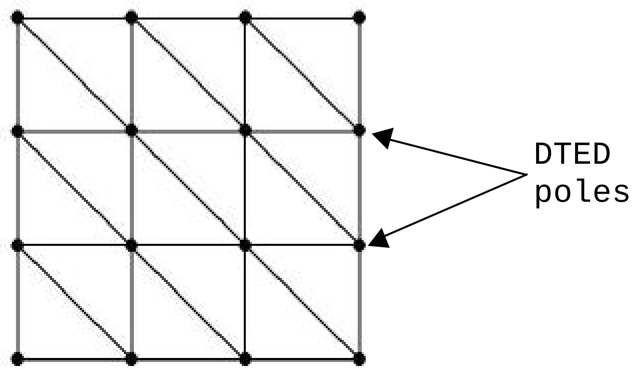


Figure 10. ModSAF Terrain Model.

## C. MODSAF LINE-OF-SIGHT ALGORITHM (MLOS)

The ModSAF line-of-sight (MLOS) algorithm uses the ModSAF Terrain Model to calculate all LOSs. MLOS is one of the best algorithms out of the family of LOS algorithms used by professional programmers and accepted by the terrain data base community [Henderson, 1999]. For further discussion on the various LOS algorithms in use, refer to Dale L. Henderson’s thesis titled *ModTerrain: A proposed standard for terrain representation in entity level simulation* [Henderson, 1999]. Henderson demonstrated that the MLOS algorithm is one of the most accurate algorithms in use. When given a start and end points within the DTED data, the algorithm connects the two points with a line segment, and stores where the line segment crosses the sides of the DTED squares and diagonals (See Figure 11).

If the line segment crosses one of the sides or diagonal of the DTED square, the algorithm does a two-way interpolation between the two DTED poles at the end of the segment to get the crossover point elevation. In the ModSAF model, the elevation at other points is a linear interpolation of the elevation at the crossover points that bracket it.

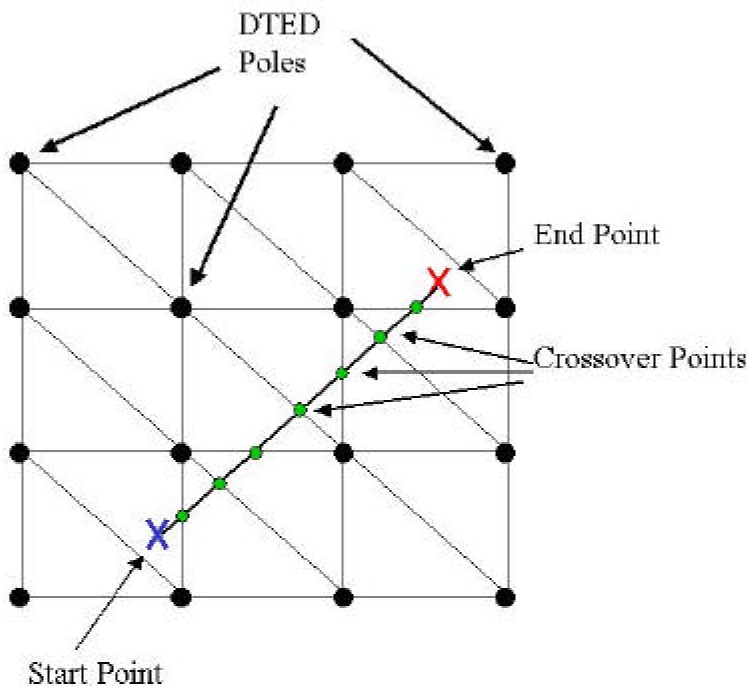


Figure 11. DTED Squares and Crossover Points.

The start point elevation is the height of the terrain plus the height of the particular optics associated with each individual platform. After all elevations are known for the crossover points, the algorithm then calculates the slopes between the start point and all intermediate crossover points. The end point can be seen from the start point if the slope from the start point to the end point is greater than the maximum slope from the start point to any other intermediate crossover points between the start and

end points. If a particular triangle can be seen from the start point, READ-Pro tags the triangle as seen and displays a light gray triangle. Any triangle tagged as not seen is transparent.

The LOS is calculated in 360 degrees around a designated point. Rays emanate from the point in equals degree intervals (See Figure 12). The degree interval is determine so that at least one ray passes through each triangle in the area of interest. Triangles closer to the point of interest, where all of the rays originate, have multiple rays passing through them. If at least one LOS ray tags a triangle as seen, the triangle is tagged as seen, even if the majority of LOS rays tag it as unseen.

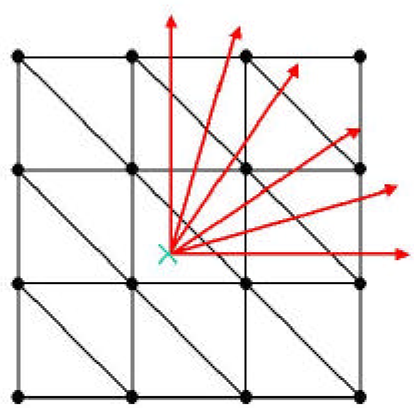

Figure 12. Line of Sight Rays

The triangular nature of the ModSAF terrain model can be seen on READ-Pro’s LOS display feature. Triangles are clearly visible (See Figure 13 and 14). A light transparent gray triangle indicates an area that can be seen.

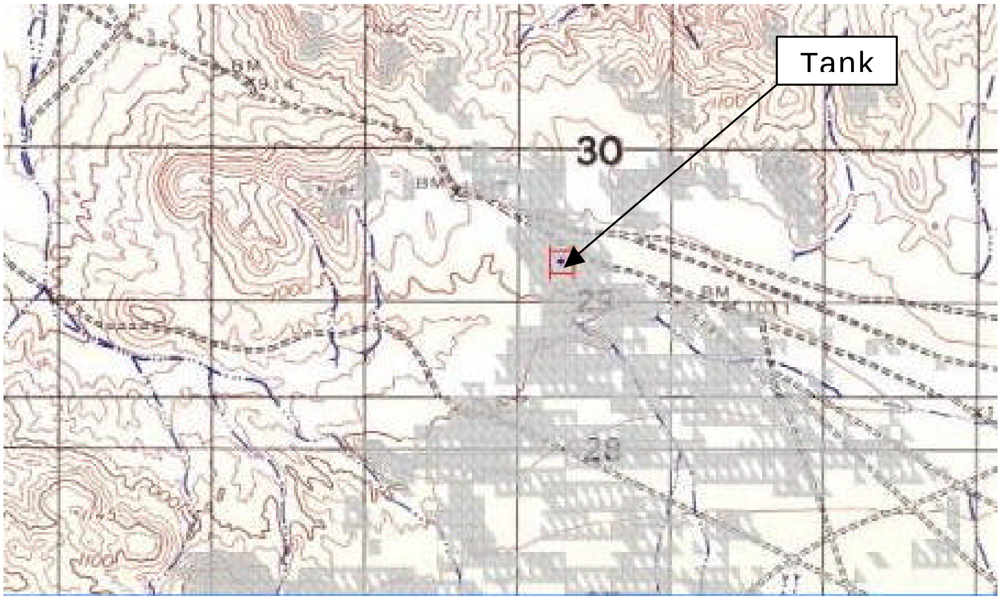


Figure 13. LOS Display from the Tank (Light Gray Means Can See).

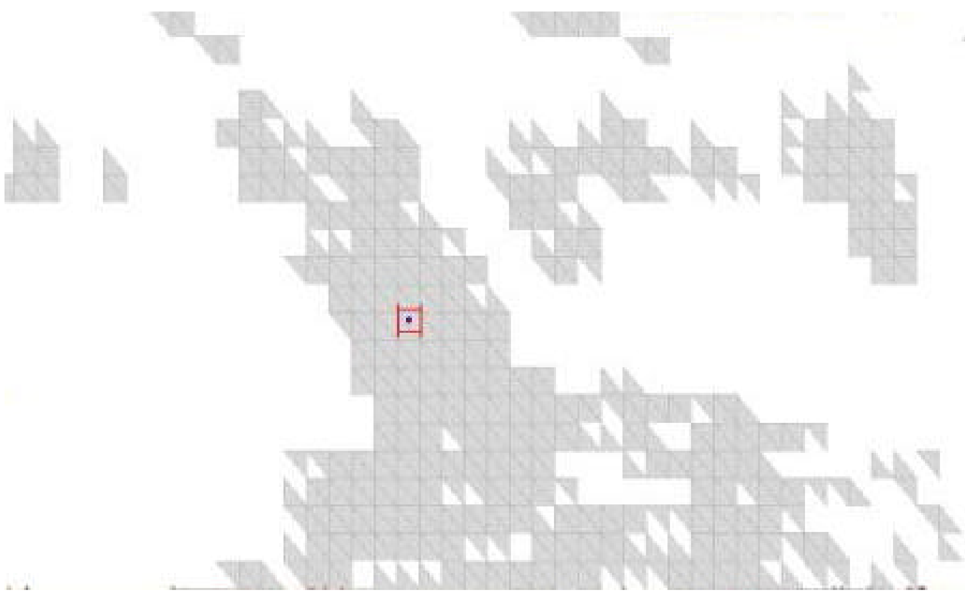

Figure 14. Line Of Sight Showing ModSAF Triangles. At a closer magnification, the triangles generated by the ModSAF terrain model are very obvious.

The ModSAF terrain model is composed of rectangles with the same ‘degree’ lengths in longitude and latitude on all four sides. At the equator, the rectangles are square. A degree in latitude is constant everywhere on the Earth. However, for longitude, the farther away from the equator, the shorter the corresponding distance between degrees of longitude. The grid squares (in the United States) are actually rectangular (See Figure 14).

The ModSAF terrain model is not perfect and is merely a representation of the real world. There are some peculiar behaviors of the algorithm that depict conditions that do not actually exist. The decision to draw the diagonal from the northwest corner to the southeast corner results in slightly different values if the other diagonal had been chosen. Certain situations could create very different behaviors. The degree of variation is determined by the resolution of DTED. Current military 1:50,000 maps have twenty-meter elevation resolution. In general, the approximation inherent in the terrain model does not have a significant impact on the LOS calculations for DTED postings that are thirty meters (DTED Level 2) or closer. As the resolution of data gets more and more accurate, the elevation calculations and thus the LOS calculations get better.

## D. PLATFORMS

READ-Pro treats all entities (vehicles and personnel) with LOS capabilities as platforms. A platform can have both a LOS capability and a direct fire capability. A M1A1 tank has a LOS capability from its optics and a direct fire

capability from its 120mm tank main gun. Some entities, such as a remote sensor, only have a LOS capability.

## E. AREA OBJECT

READ-Pro’s MOEs compare platforms with area objects. An area object is a polygonal area of terrain. Obstacles, named area of interest (NAI), Engagement Area, and EA quadrants are all treated as areas. An obstacle area is the physical obstacle dimensions plus the rectangular area of interest surrounding the obstacle.

## F. MEASURES OF EFFECTIVES

The first five measures of effectiveness are straightforward area coverage calculations. The different areas are divided up into a matrix of triangles created by the ModSAF terrain model. If any of the platforms can see into a triangle, the triangle is tagged as seen. The MOEs calculate the ratio of seen triangles to the total triangles in the selected area.

MOE 6 measures the fragility of a commander’s defense. In order to measure how much a particular defense depends on only a few vehicles, MOE 6 recalculates MOE 1 with all emplaced platforms minus a selected percentage of ‘destroyed’ vehicles. The commander designates the desired endstate of remaining friendly forces for a given mission, such as 75 percent of the company still combat effective. This implies that the unit can lose 25 percent of its forces and still be mission capable. A uniformly distributed random integer ranging from 1 to the total number of platforms emplaced by the commander is generated.

Each of the integers corresponds to one of the vehicles emplaced by the commander. If the vehicle associated with the random integer has not been previously selected, it is removed from the array of emplaced vehicles. If it has already been selected, the random integer is discarded and a different one generated. This process is repeated until the number of vehicles removed equals the percentage of vehicles designated by the commander as acceptable to be destroyed (i.e. 25 percent of total vehicles emplaced). Once the appropriate number of vehicles have been removed, MOE 1 is recalculated using the reduced array of vehicles. This value is stored for a single iteration. Using Monte Carlo Simulation, this process is repeated and averaged over the number of iterations (for example 10,000). The resulting value, MOE 6, gives an estimate of the average percentage of the engagement area covered by 75 percent of the vehicles. READ-Pro rounds all fractions of vehicles to the next largest whole number. For example, 25 percent of 14 vehicles is 4 vehicles, not 3.5. The larger the difference between MOE 1 and MOE 6, the less redundancy and the greater fragility of the defense.

The direct fire control matrix calculates coverages broken down by subunits or platoons. The areas the platoons are compared against are one of the following: engagement area, EA quadrants, obstacles, or NAIs. The percent coverage is calculated once the user develops the direct fire-planning matrix (See Figure 15). The commander sets a minimum threshold of coverage that triggers a pop-up window that informs the commander that the particular task is in jeopardy due to a low coverage percentage (See Figure

15). The commander receives immediate feedback as he tasks his subunits.

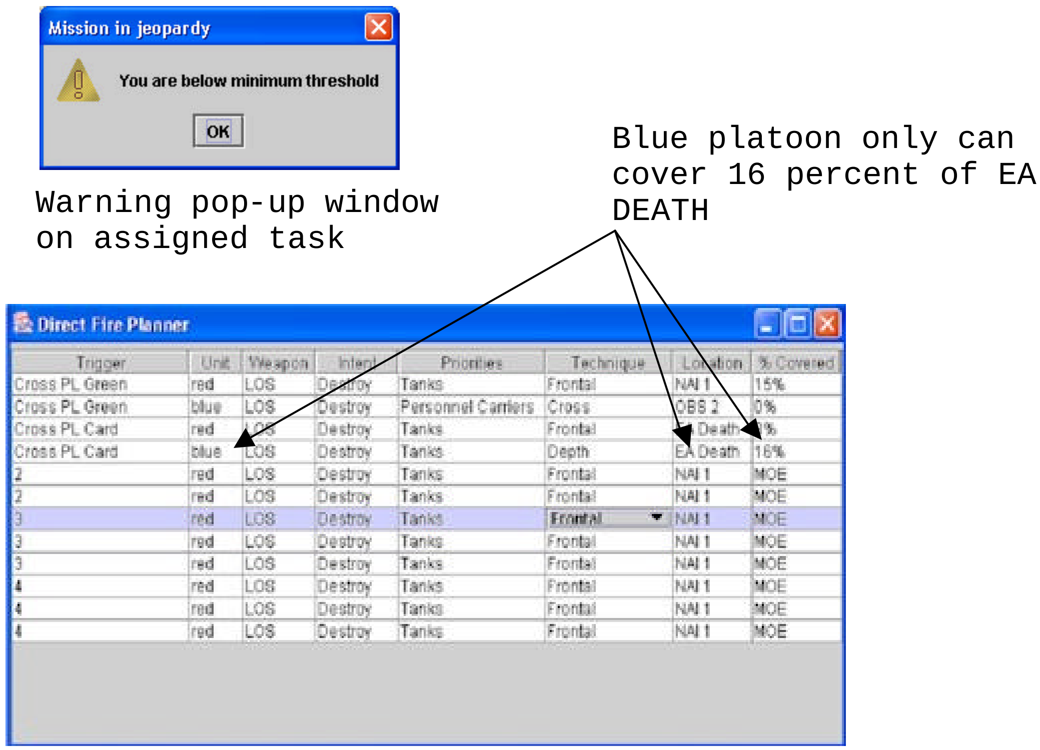


Figure 15. Direct Fire Control Matrix.

## G. INDIRECT FIRE FEEDBACK

READ-Pro provides visual feedback on the servicing units of emplaced indirect fire targets. Once a commander emplaces a target reference point (TRP), it is color coded with a circle around the cross hair based on the firing units capable of servicing the target (See Table 3 and Figure 16).

The color codes are the following:

| Circle color | Firing units |
|---|---|
| Red | None |
| Blue | Only mortars |
| Yellow | Only artillery |
| Green | Both mortars and artillery |

Table 3. Indirect Fire Feedback.

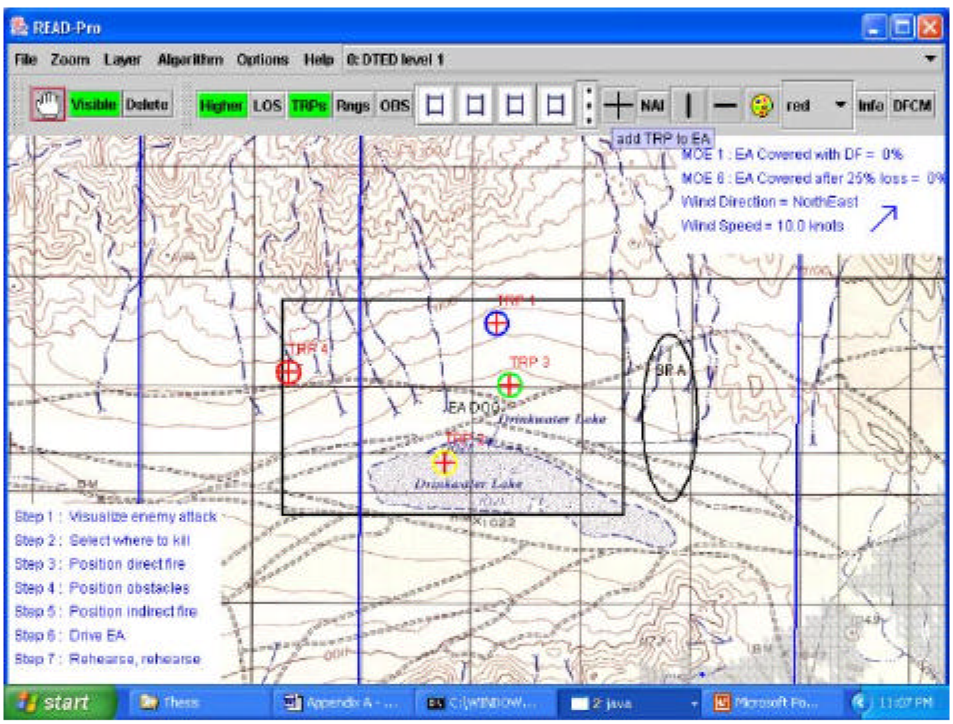


Figure 16. Indirect Fire Screen Shot.

The colored feedback provides the commander with more information on what he should expect from each target. For instance, if a smoke target is supported by 155mm self-

propelled artillery versus 81mm mortars, the effect, duration and responsiveness are drastically different. The mortars are more responsive but the effect and duration of the smoke by the artillery is far superior.

## H. IMAGE FADING CAPABILITY

READ-Pro enables the commander to fade images in and out. This feature allows the commander to superimpose a military map over a satellite image (See Figure 17). The commander can superimpose real-time satellite feeds from an unmanned aerial vehicle or some other intelligence source over the map he used for planning. This feature can be used to verify unit locations or such things as the status of a bridge.

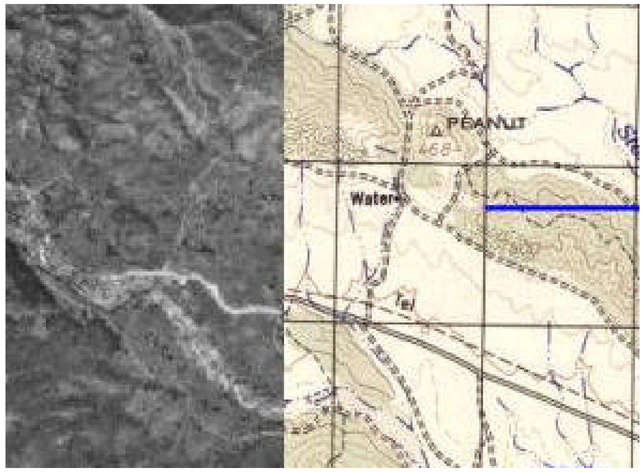


Figure 17. Satellite Image Covered by Opaque Map.


Figure 18. Image Fading Feature. Map at High Transparency Level to Expose Satellite Image Underneath.

## I. BATTLEFIELD METRICS

With advances in technology and remote sensors, it is feasible to track the status of many unit characteristics such as communications, weapons, ammunition, fuel, water and food status. This information is updated continuously either by subordinates or through sensors. By double-

clicking on each vehicle, the individual vehicle metrics are displayed. The six metrics are given in percentage remaining or percentage operational using a color scheme of green (75-100%), yellow (26-74%), red (11-25%), and black (0-10%)(See Figure 18).

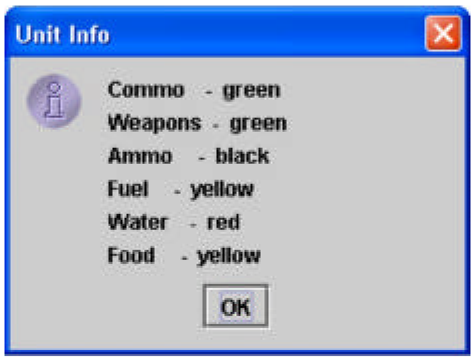


Figure 19. Vehicle Metrics.

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# III. TROOP-LEADING PROCEDURES WITH READ-PRO

## A. INTRODUCTION

The previous chapters discussed the current tactics, techniques, and procedures used by the Army to develop engagement areas. They also highlighted the shortcomings and common problems affiliated with performing traditional EA development in battle conditions. They also demonstrated the functions and benefits of using READ-Pro. The following notional scenario puts READ-Pro into a real context. The story follows the company commander of Alpha, 1-66 Armor battalion, CPT Burger. His unit just recently installed the READ-Pro system into all of their command and control vehicles. He is currently conducting operations in a foreign country. CPT Burger’s company is cross attached to 3-67 AR, a unit that he normally does not work with and in an area far away from his present location. This story highlights many of the situations where the READ-Pro system could be used.

## B. CHANGE OF MISSION

Captain Burger and his driver were in route to 2nd platoon’s assembly area to check on his soldiers. Halfway there CPT Burger received a message over the radio from his battalion commander, informing him that his company had been cross-attached to 3-67 Armor battalion. There was a meeting scheduled in one hour to discuss the details of his new mission at the 3-67 AR’s battalion tactical operations center (TOC). His driver informed him that it would take approximately 45 minutes to get to the meeting location.

CPT Burger promptly ordered his driver to forget about 2nd platoon and head to the meeting.

CPT Burger turned on his flat screen monitor mounted on the dashboard of his Humvee, and initiated a secure link to the brigade intranet. He powered up READ-Pro and prepared to download any available information. Unaware of 3-67 AR's mission and what they had in store for his company, he wanted to see what information had been posted on the network. It was his hope that details of his mission were already available. That way, he could use the next 45 minutes to get a head start on his mission analysis and company operations order.

Upon completing a secure link, CPT Burger accessed all available 3-67 information. Since he had to move his unit 80 miles to the north through unfamiliar territory in order to link up with 3-67 AR, his first concern was to give his unit a warning order about their mission and get them prepared to move. It was already getting dark and he wanted to move as soon as possible. Waiting until after he received the operations order from higher to begin movement would mean conducting the roadmarch in the dark. He searched for operational graphics of the new area of operations (AO). The benefits of this new READ-Pro system were immediately evident. He found graphics that were updated just one hour earlier. Although he would leave the details of the move to his company executive officer (XO), CPT Burger wanted to do a rough mission analysis of the route to the new assembly area (AA).

He input the current location of his unit and plotted a straight-line distance to the new assembly area. He

noticed that regardless of how they approached the new AA, his unit would have to drive through a newly cleared minefield. Fortunately for him, the cleared lane was just completed that morning and posted two hours earlier. The minefield graphics were accurate to 1 meter and constantly updated as the lanes were widened. If he used his imagination, it was as if he could watch individual mines disappearing. With this information, he wanted to make sure his company's route incorporated the fact that they could only gain access through one control point.

CPT Burger then radioed his company TOC and told his XO, 1LT Cox, of the new mission. 1LT Cox acknowledged and informed him that the TOC actually received a heads-up once the new order was sent via the intranet. His XO said that the unit would be moving by the time CPT Burger returned and therefore established a link-up with the commander 40 miles from the current AA.

Now that the unit was preparing to move, CPT Burger shifted his focus to his next mission. 3-67 AR wanted his company to establish a hasty defensive position to the north of 3-67 AR. Alpha Company was to secure the northern flank from any counter-attacking forces while 3-67 AR clears a town just east of Alpha Company's position. The maneuver graphics already had a tentative company battle position, BP DOG, and engagement area, EA SABER posted. The unit would not get to the new AA until nightfall. Based on the forecasted illumination of only two percent, the leader's recon will be very difficult. Sighting in fighting positions and obstacles at night is an extremely challenging task and usually results in unfortunate

decisions that become obvious at sunrise. Using READ-Pro to examine the surrounding terrain, CPT Burger found that he can give his platoon leaders better tentative locations for their individual vehicles than he can with a paper map reconnaissance. He explored the line-of-sight from DOG to SABER. By clicking on various locations, and observing the line-of-sight fans displayed, he determined that BP DOG did not take advantage of the high ground just behind the BP. Most likely, he would array his platoons a little behind the BP for maximum effectiveness.

CPT Burger divided his company into three platoons, Red, White and Blue. All three were M1A1 tank platoons. He wanted to ensure that he could cover the most of the EA from his positions. After a little trial and error, he found three platoon positions; each with 4 tanks. Red platoon, on the east flank covered the majority of the EA, approximately 45 percent, with White and Blue at approximately 30 percent. Although the positions seemed to give adequate covered of their assigned sectors within EA DOG, CPT Burger observed that the fragility measure of the defense was very high. His positions either had little overlap or relied heavily on a few vehicles. If his company lost these vehicles there would be large gaps in his coverage. He explored where this could have occurred. He discovered that both Red’s and White’s platoons coverage was mainly due to a single vehicle in each platoon. He moved the other vehicles around in the battle position so that they had better fields of fire and provided overlap with each other. After a little analysis, he not only reduced the fragility of the defense, but improved his coverage by 10 percent in each platoon.

Based on Red platoon's location, Red platoon had to remain combat effective throughout the course of the battle in order for company mission to succeed. They were responsible for both a critical obstacle and they covered the enemy's main avenue of approach. Just then, 1LT Cox radioed. He informed his CC that they just were given enough bulldozer time to dig six fighting positions and wanted to know who were the priority platoons. Having just figured the importance of Red platoon, CPT Burger let the XO know that the priority was Red platoon (4 fighting positions), the TOC (1 fighting position), and finally the FIST vehicle (1 fighting positions).

Next, CPT Burger developed the obstacle and indirect fire overlay to complement the locations of his tanks. Although his subject matter experts would most likely refine them, his intent was clear. He used the obstacles to canalize the enemy into a target area of interest. The indirect fire targets supplemented the direct fire systems and covered some of the dead space. Based on the target locations, he used READ-Pro's line-of-sight feature to assign primary shooters and observers for the targets. This was key in that it allowed the observers to ensure that they had good line-of-sight of their assigned targets once they were on the ground.

As the driver came to a stop in front of 3-67 AR TOC, CPT Burger sent all of his subordinates his tentative plan. His meeting would take about two hours. During that time, his subordinates could begin their troop-leading procedures and get the unit moving towards the new objective. Using the same tool, READ-Pro, the platoon leaders could do a

more detailed analysis of the terrain in their designated platoon battle positions. Once each platoon completed their individual analysis, the leader’s recon, conducted later that evening, will ‘validate’ their plan instead of ‘develop’ it.

# IV. NTC SCENARIO DEMONSTRATION

## A. INTRODUCTION

The following scenario is from an order given at the National Training Center in 2002 [Moore, 2002]. The scenario demonstrates how using READ-Pro helps indicate characteristics of a poor defense. A mechanized battalion task force composed of 2 M1A1 Abrams tank companies and 1 M2A3 Bradley fighting vehicle company are task to defend an area known as Drinkwater Lake (a dry lake) in order to prevent the enemy from reaching their main objective farther to the east. The enemy consists of a motorized infantry brigade (MIBR) broken down into 3 motorized infantry battalions each containing 10 T-80 tanks and 30 BMP infantry fighting vehicles. Enemy doctrine and intelligence indicates that the enemy will attack in two echelons. The first echelon consists of one reinforced MIB whose task and purpose is to attack across the frontage of the friendly forces in order to identify a weakness and point of penetration in the defense for the second echelon to exploit. Once the penetration point is identified, the second echelon, consisting of two MIBs, fixes the friendly forces so that they cannot reinforce the point of penetration. Once the friendly forces are fixed, the main body of the second echelon exploits the point of penetration.

The friendly forces have emplaced a linear defense just east of Drinkwater Lake. The companies are aligned north to south, B Company with Bradleys, A Company with tanks, and D Company with tanks (See Figure 20).

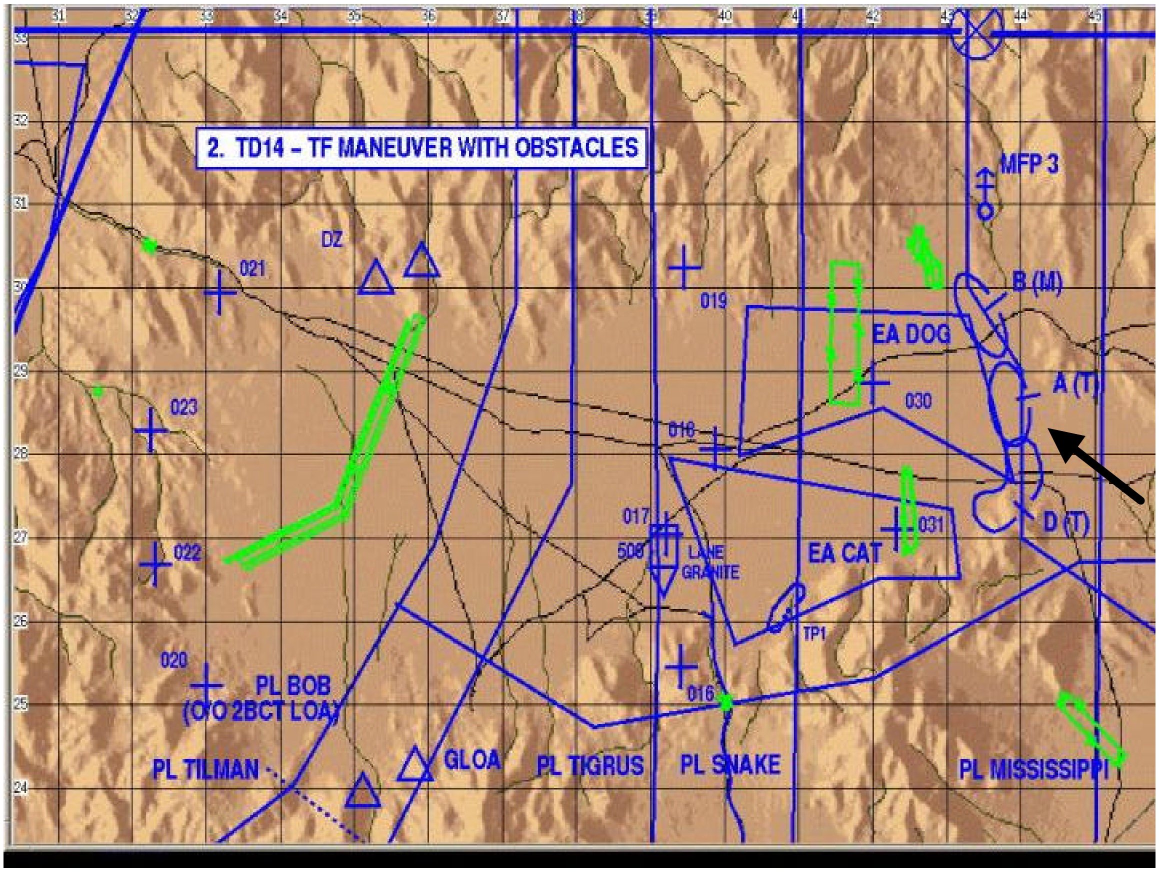


Figure 20. Actual Planned Graphics from NTC Rotation.

For demonstrative purpose, only Company A (See Figure 21), the tank company located in the center battle position, is followed in the scenario. All graphics that do not directly affect Company A are disregarded.

## B. CRITIQUE OF DEFENSE

Three observations from the Cobra observer/controller (O/C) team assigned to this unit were the following [Moore, 2002]:

1. Many subordinates did not have a full understanding of the 7 steps of developing an engagement area.

2. Situational obstacles were not completely arrayed against multiple enemy courses of action and their execution was not tied to decision points or clearly defined.

3. Commanders did not develop a direct fire plan to clearly focus the platoons on the enemy and distribute the fires of the companies over different parts of the enemy formations. This prevented the unit from massing on the enemy throughout the depth and width of their battlespace .

Observation 1 and 3 are addressed by using the Real-time Engagement Area Development Program. The analysis is developed using 7 troop-leading procedures and 7 steps of engagement area development. The 7 steps are constantly displayed in the lower left-hand corner of the screen. Although seeing the steps does not imply an understanding of their meaning, the way the user interacts with the system reinforces their underlying principles.

Observation 3 by the O/Cs is particularly pertinent to READ-Pro since this program has the ability to develop a direct fire control matrix. The commander can assign different units various areas of responsibility and get feedback on their ability to accomplish these tasks.

One major flaw in the defense is that there is a very large dead space east of the obstacles (See Figure 21 and 22). The obstacles have sufficient direct fire coverage (See Figure 23), but if the enemy gets through or goes around them, the company will have a difficult time destroying the enemy due to lack of LOS.

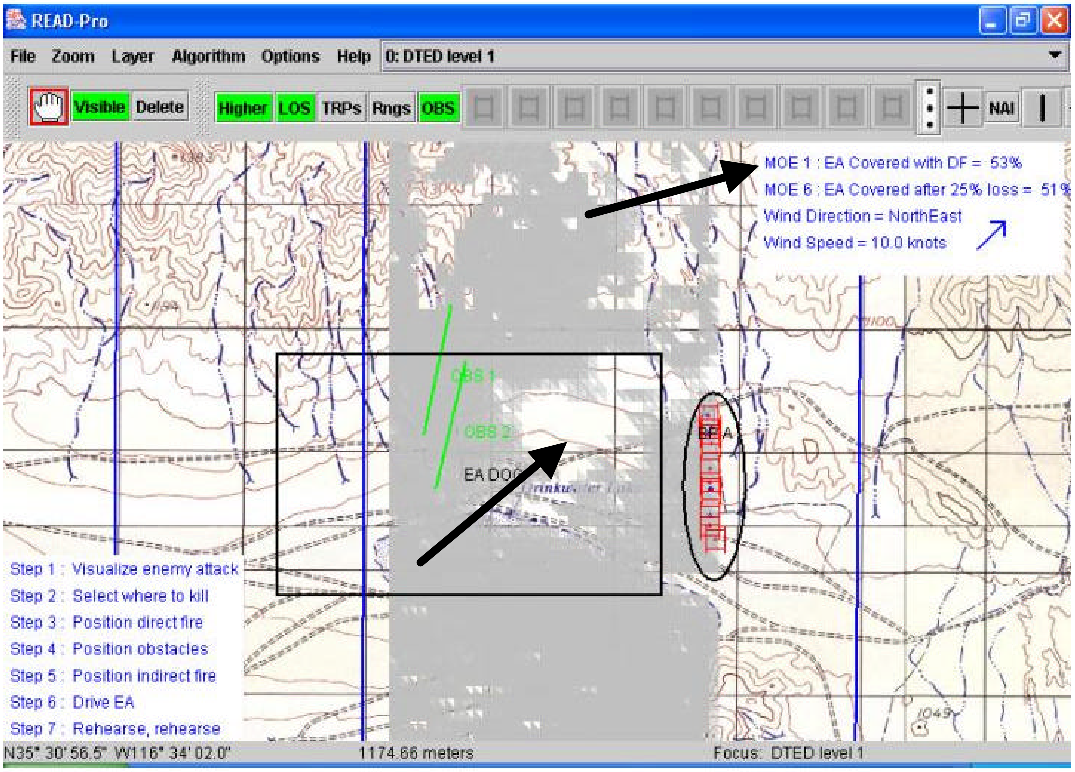


Figure 21. LOS From Vehicles Showing Dead Space.

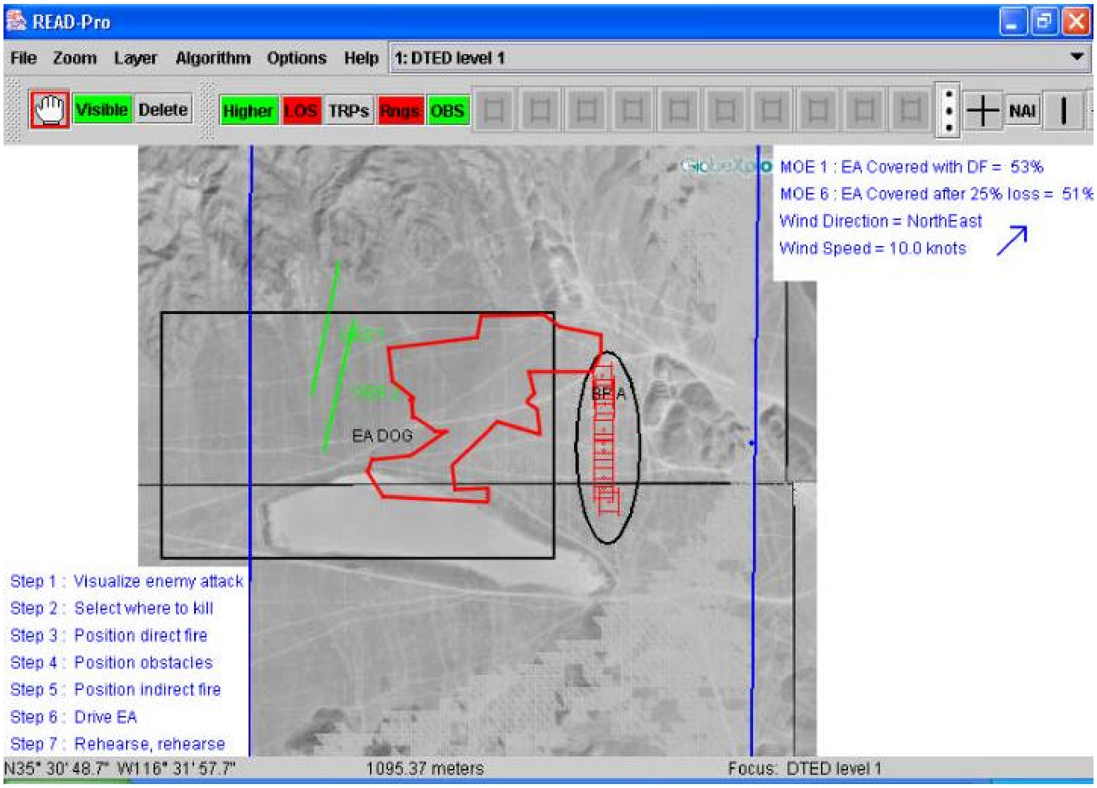


Figure 22. Dead Space Overlaid on a Satellite Image.

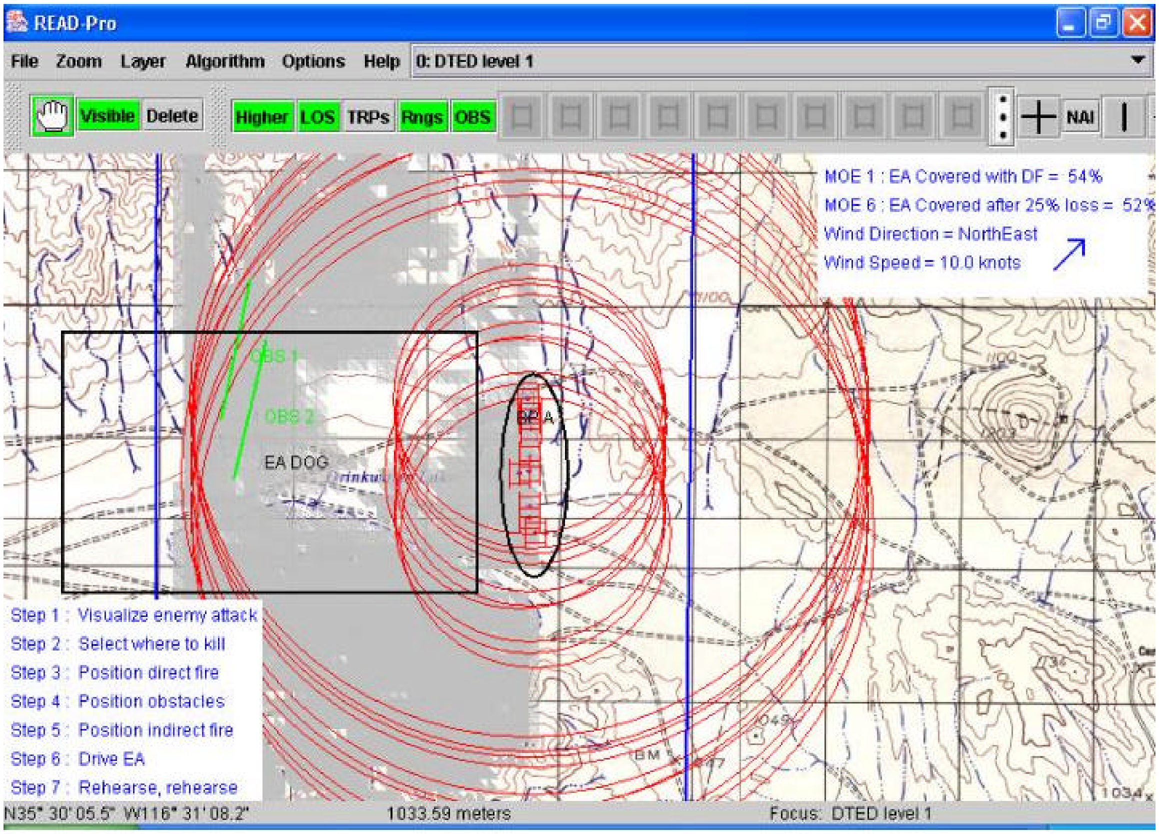


Figure 23. Range Circles of Defense.

Similar to observation number three made by the O/Cs, MOE 1 (54% EA coverage) indicates that half of the EA must be covered by another means such as indirect fire. If the EA is where direct fires are massed to kill the enemy, half of the assigned battle space is not used. This could cause a problem if the killing systems available cannot destroy the enemy in the reduced battle space fast enough. Attacking across the depth and width of the enemy formation is critical in order to maximize the defense's effectiveness. If the engagement area is too small, the enemy could saturate even a good defense. MOE 1 and MOE 6 are 54% and 52% respectively. This implies that all of the

vehicles have relatively the same LOS. Unfortunately, it is virtually impossible for the northern vehicles to support the southern vehicles if they are penetrated without repositioning and leaving their primary sectors uncovered.

## C. IMPROVED DEFENSE USING READ-PRO

Without changing the location of the other companies and battalion level graphics such as obstacles, Company A's battle position can be drastically improved by taking advantage of the surrounding terrain (See Figure 24). With the original locations, MOE 1 and MOE 6 are 54% and 52%. By spreading out the platoons and using the high ground to the east, the company can increase its survivability and reduce the dead space in the EA (See Figure 25).

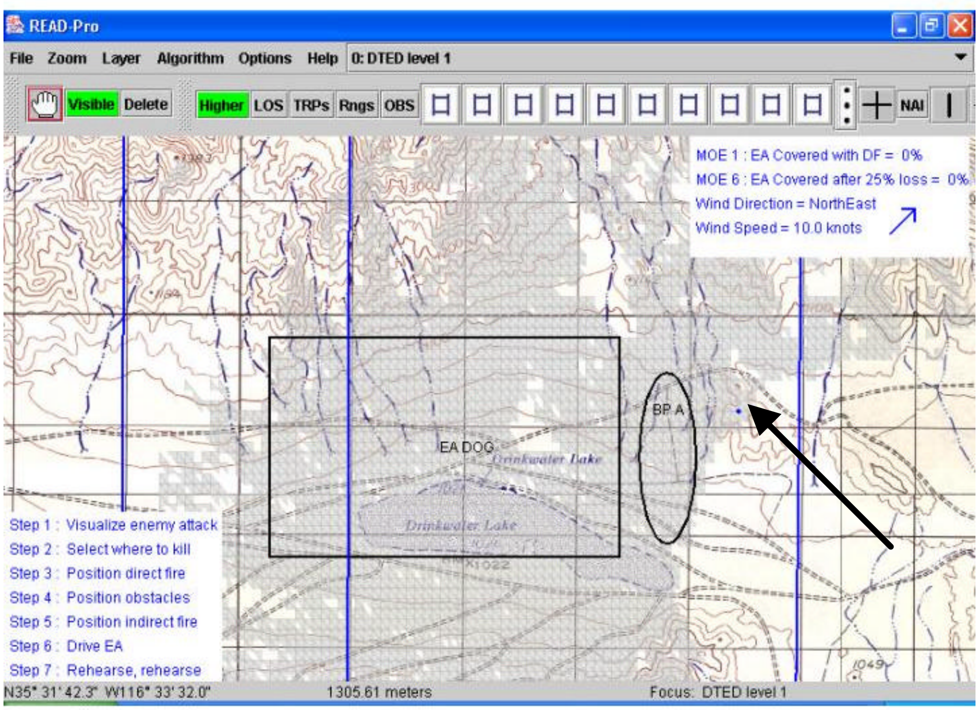


Figure 24. Greater Visibility on High Ground.

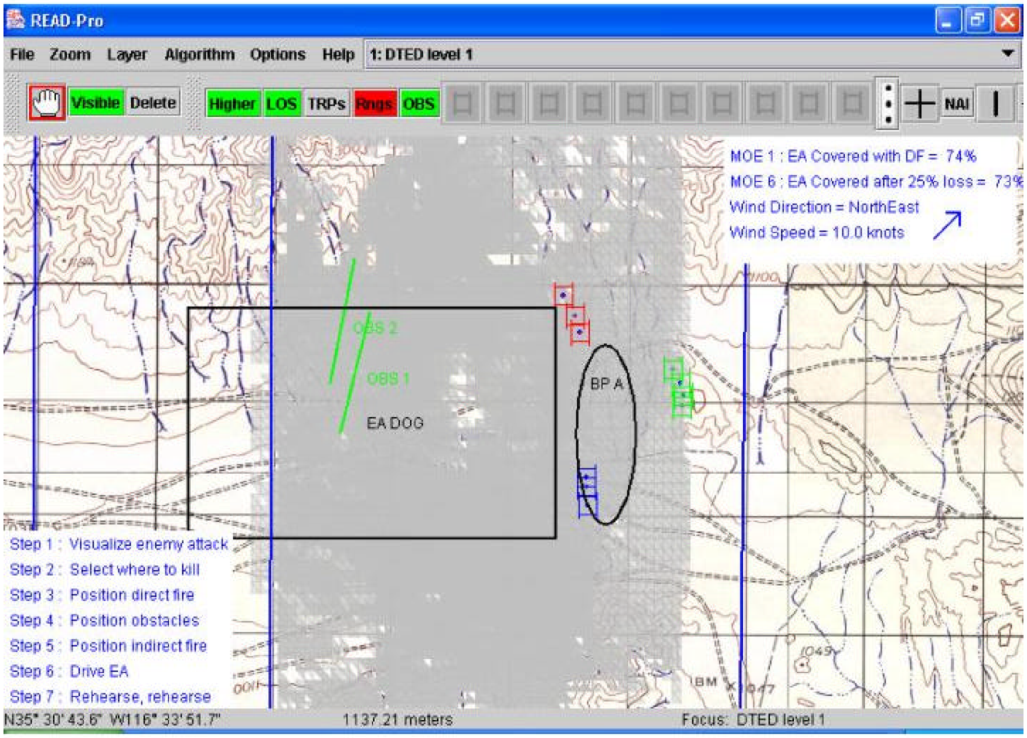


Figure 25. Improved LOS with New Positions.

The dead space is virtually gone. Additionally, the enemy is presented with a much larger frontage compared to the original positions. Repositioning the platoons has increased their EA coverage by 20 percent, from 54% to 74% (MOE 1). MOE 6 also improved to 73%, only 1 percent less than MOE 1.

By moving Green platoon closer to the high ground to the east, they now have a vantage point that looks into the previous dead space. Green platoon is no longer responsible for destroying the enemy west of the obstacles. Their primary task is to destroy the enemy that penetrates the breech (See Figure 26). This change in responsibility is reflected in the direct fire control matrix.

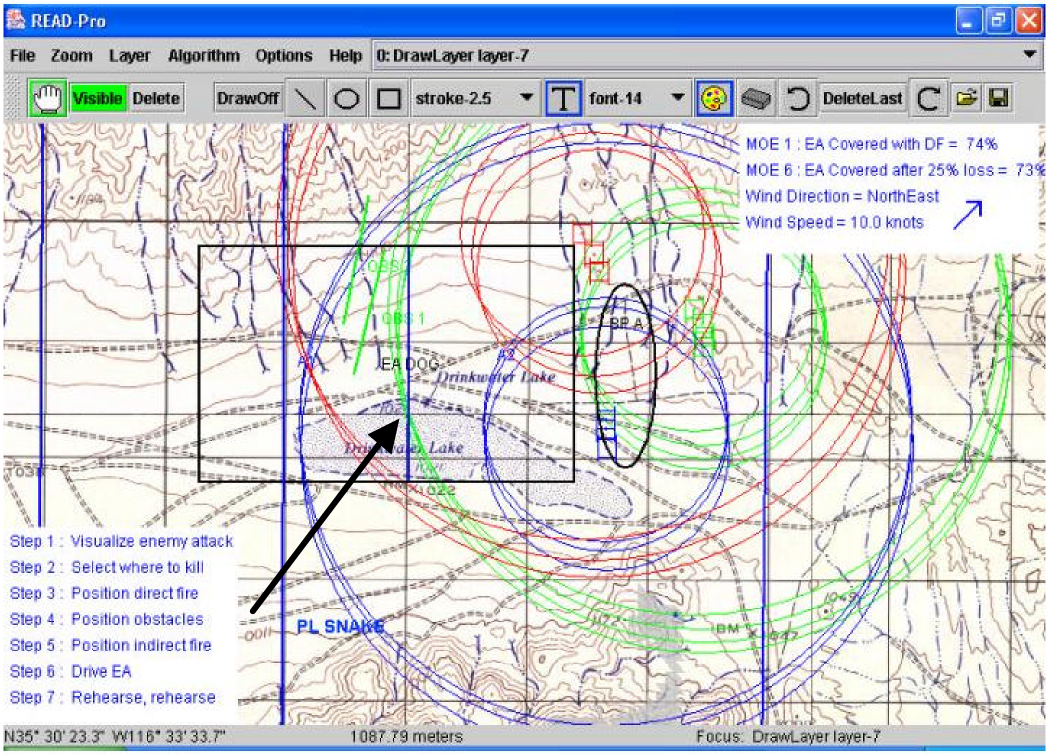


Figure 26. Range Circles Show Areas of Responsibility for Each Platoon.

In order to control direct fires, the engagement area is divided in half just east of the obstacles. This division corresponds with the maximum effective range of Green platoon (See Figure 27). Quadrant A1 is in the West and quadrant A2 is in the east (See Figure 28).

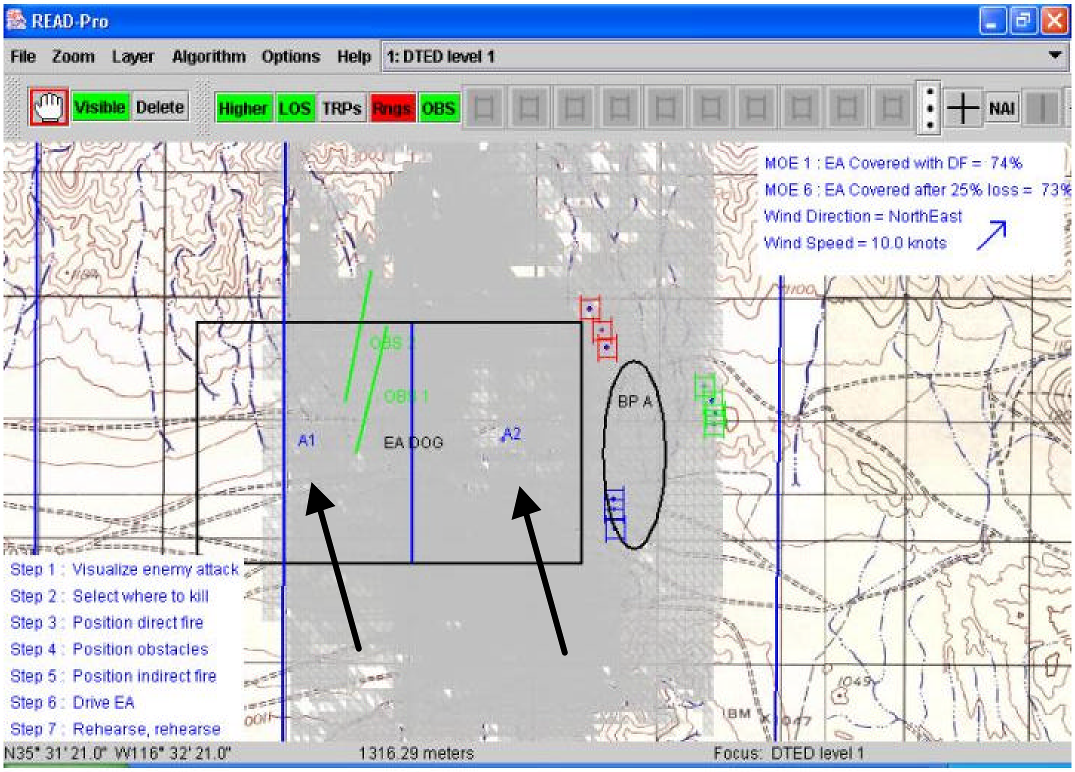


Figure 27. Engagement Area Divided into Quadrants.

With the two quadrants, each platoon is given an area of responsibility based on various triggers (See Figure 28). Red and Blue platoons are responsible for enemy vehicles in the western half of the EA and Green platoon is responsible for enemy vehicles in the eastern half of the EA. This plan incorporates destruction on both the width and depth of the enemy formations.

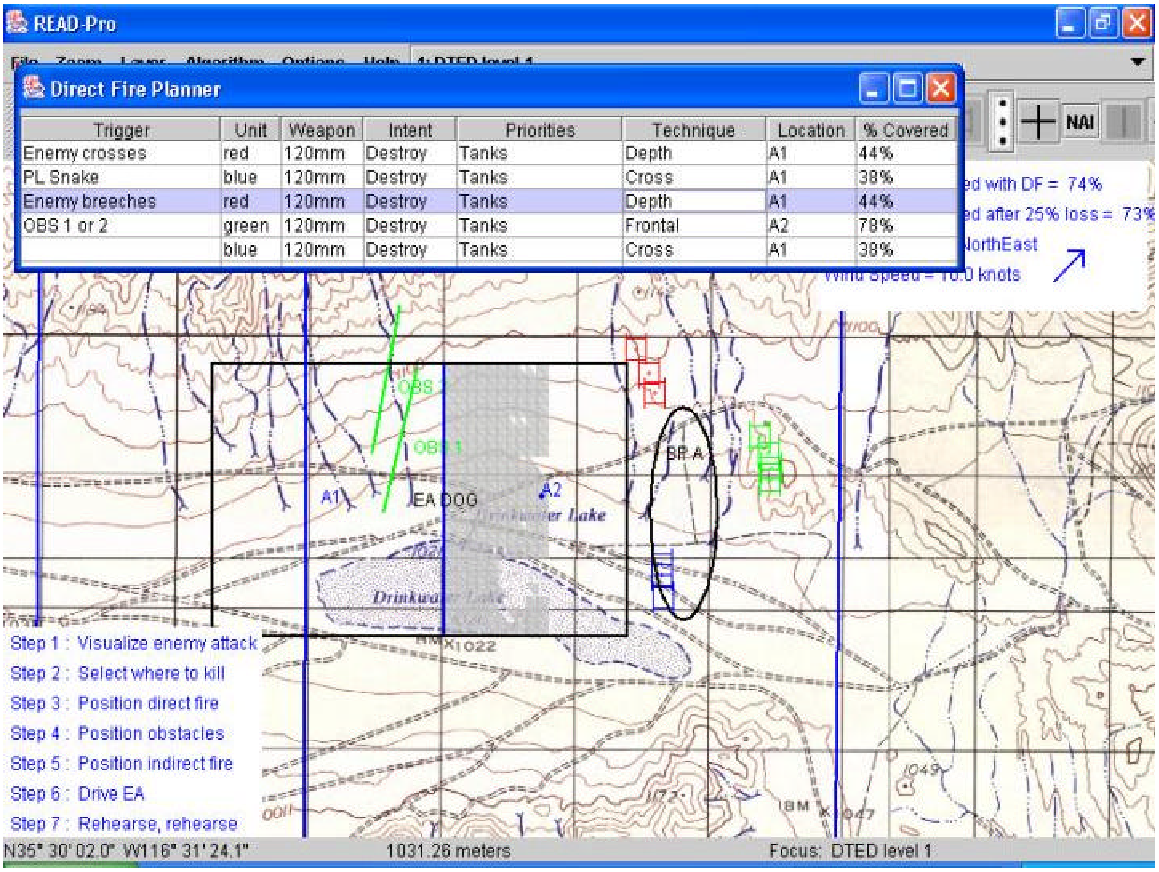


Figure 28. Direct Fire Control Matrix of New Defense

As demonstrated with the defense from NTC, READ-Pro significantly enhances the written critique of the fundamentally flawed defense by presenting the commander with a visual display of the coverage and quantitative measure of its fragility. READ-Pro also supports the rapid evolution to a better defense by providing visualization of the coverage and quantitative evaluation at each step in the engagement area development process.

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# V. READ-PRO BASED DESIGN

## A. PROTOTYPE

READ-Pro combines many concepts in use today. The ModSAF terrain model, Java programming language, and the engagement area development process are all proven ideas. The uniqueness of READ-Pro is in the way it integrates these ideas into one dynamic system. READ-Pro is built on existing military concepts and contemporary technological products. An operational system based on READ-Pro could be designed and built now. The READ-Pro design is compatible with many of the anticipated upgrades and advances in terrain and mapping techniques. It operates on a stand alone PC but is most beneficial when coupled with an information and command and control network.

READ-Pro can be used as a benchmark for the future procurement of an actual system. It can also be used to evaluate current contour maps against various levels of DTED data. Finally, improving the system by incorporating a 3-D representation of terrain is very possible with the Java programming language.

## B. FULL SPECIFICATIONS

The following is a tentative list of the full specifications for an operational system. Many of these specifications are demonstrated by READ-Pro, others are only possible given a network hierarchy and a fully operational system.

- Universal and instantaneous dissemination of information

    - Maps
    - Graphics/overlays
    - Orders
- Reduce human error
    - Do not have to copy graphics
    - Increased communication security since there are no hard copy products to lose
- Reduce reproduction of products
    - Save time – not done by hand
    - Fewer errors – not done by hand
- Real-time feedback as to feasibility of task
    - MOE – Percent of engagement area covered by entire unit’s LOS
    - MOE – Fragility of defense
    - MOE – Area coverage by selected subunit
    - Indirect fire target servicing unit (method of engagement)
- Explore multiple courses of action
    - Rank order COAs
- Fewer refinements to plan when on actual terrain
    - Results in more time to execute plan
    - Refinements will be less drastic and result in fewer changes to fundamentals of plan
- Use more information in decision making
    - Easily access all information from higher and lower
        - Satellite imagery
        - Modified Combined Obstacle Overlay
        - Friendly maneuver graphics of all units
            - Adjacent units
            - Own unit

        - Enemy courses of action
        - Reconnaissance and surveillance plan
        - Indirect fire matrix
        - Obstacle overlay
        - Operations order (higher and lower units)
        - Decision Support Template (DST)
    - No need to memorize or look up information
        - Most recent and accurate information
        - Graphical representation of information
        - Subconsciously use graphical feedback in decision making
    - Environmental information
        - Wind speed
        - Wind direction
        - Temperature
    - Range of weapon systems
    - Assets available
        - Vehicle status
            - Ammo
            - Fuel
            - Other characteristic
- More accurate plan allows the commander to execute plan sooner and without fear of drastic change once on the ground
    - Commit low density resources earlier that are not logistically flexible
- Create extendable markup language (XML) scenario

    - Export to higher or lower
    - Export to simulation (i.e. Combat XXI) to run iterations and get feedback
- Software design so the program can improve as better resources are available
    - Updated map and/or graphics
    - More accurate DTED
    - Real-time satellite imagery
- Generate products
    - Reconnaissance and surveillance plan
    - Obstacle overlay
    - Indirect fire overlay
    - Maneuver graphics
    - Direct fire control planning matrix
- User friendly graphical user interface (GUI)
- Program allows user to manage and use more information
    - Prevent information overload

# VI. CONCLUSION

READ-Pro provides the lower level commander with many technological advances currently not available to him. It assists the commander in accessing and managing large amounts of information and through a user-friendly graphical user interface, the commander can develop an engagement area using standard doctrine, techniques, and procedures. READ-Pro expedites the engagement area development process by providing increased access to information coupled with real-time analysis and instantaneous dissemination of information.

READ-Pro is a decision support tool that provides the commander a means to evaluate a given defense both visually and quantitatively. It also supports the rapid evolution to a better defense by providing visualization of the coverage and a quantitative evaluation at each step of the engagement area development process.

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# APPENDIX A READ-PRO DEMONSTRATION

This appendix walks through most of the functions and graphical user interfaces found in READ-Pro.

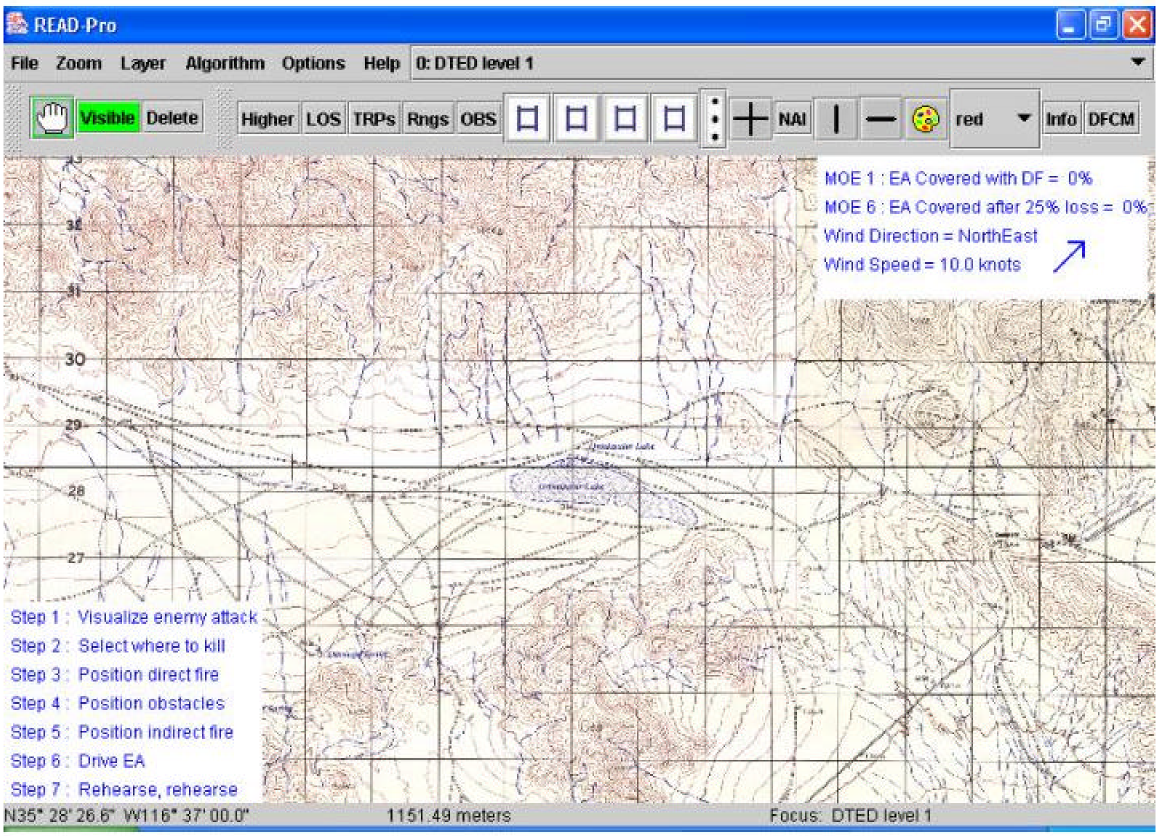



Figure 29. Standard Graphical User Interface. GUI for READ-Pro running on Windows 2000 shown with a 1:50,000 map of the National Training Center.

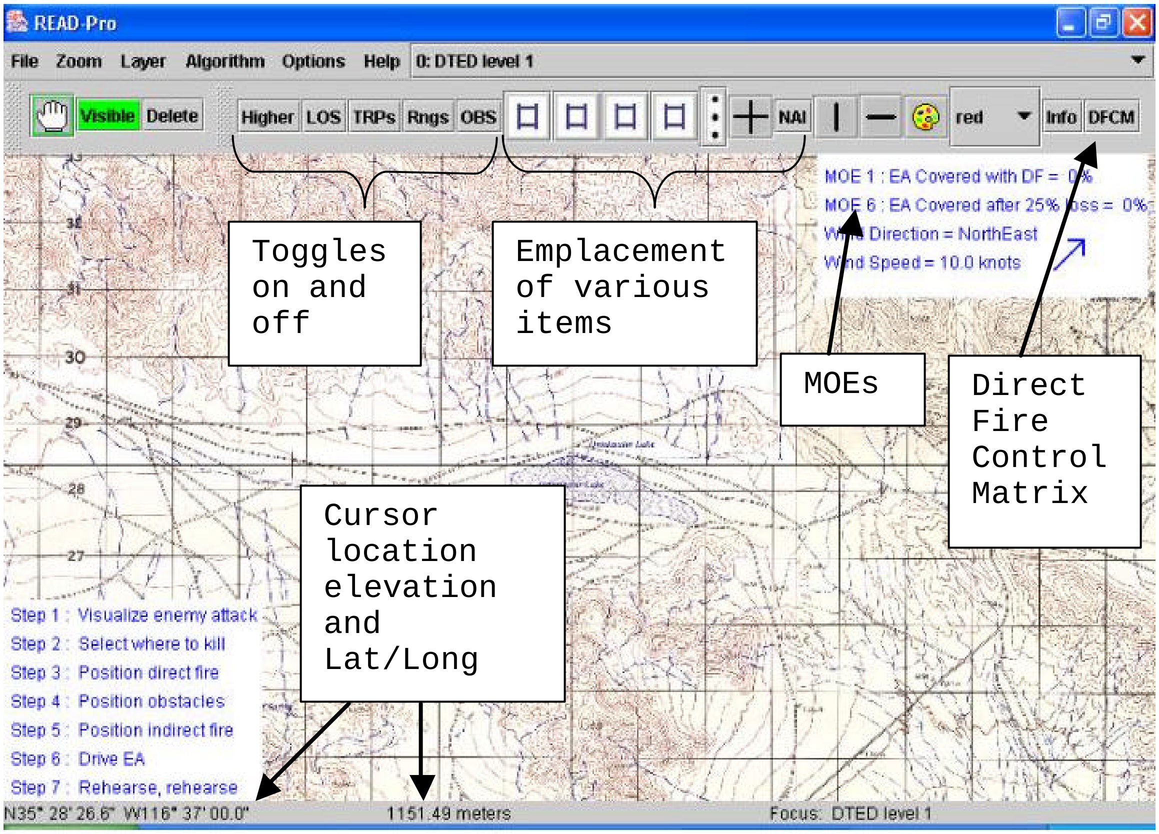



Figure 30. General Orientation to GUI. A green colored button means ‘ON’. A red colored button means ‘OFF’. A gray colored button means not currently activated but available.

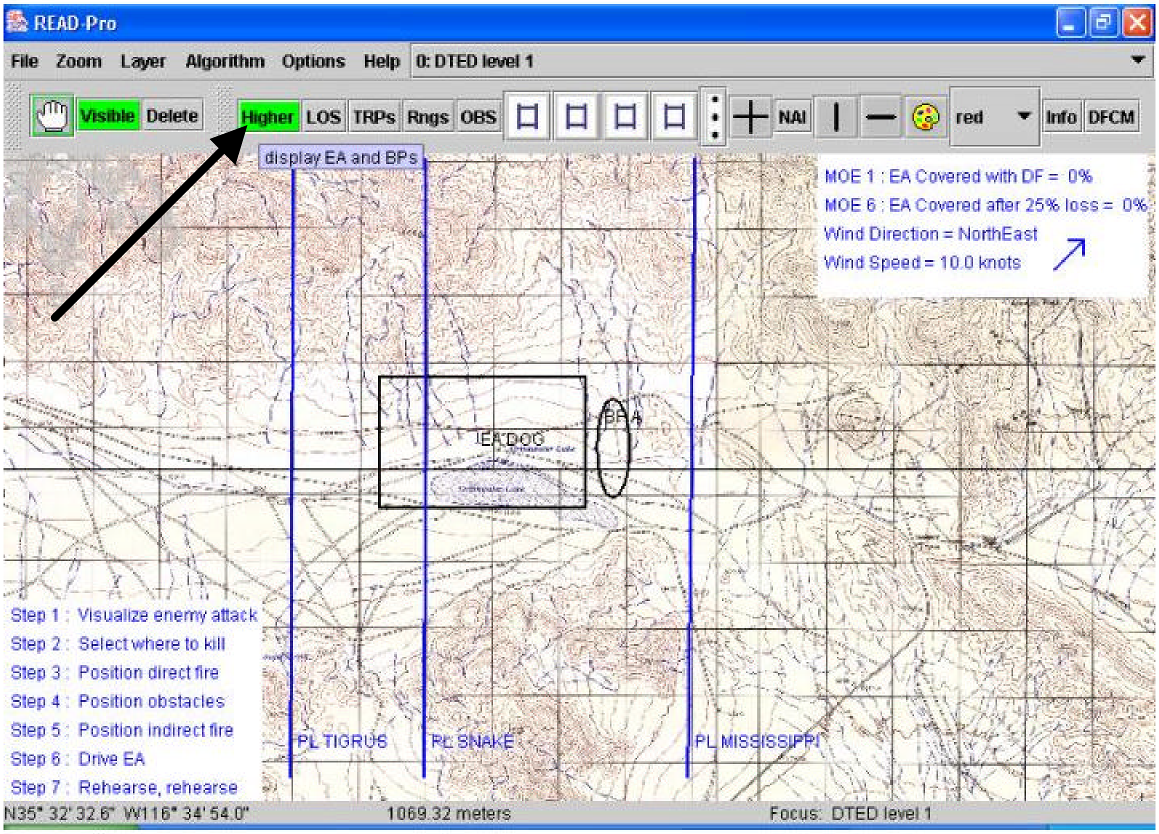



Figure 31. Higher Button. Downloads all maneuver graphics and weather data available from Higher command. Simulates getting a real-time link through a secure intranet.

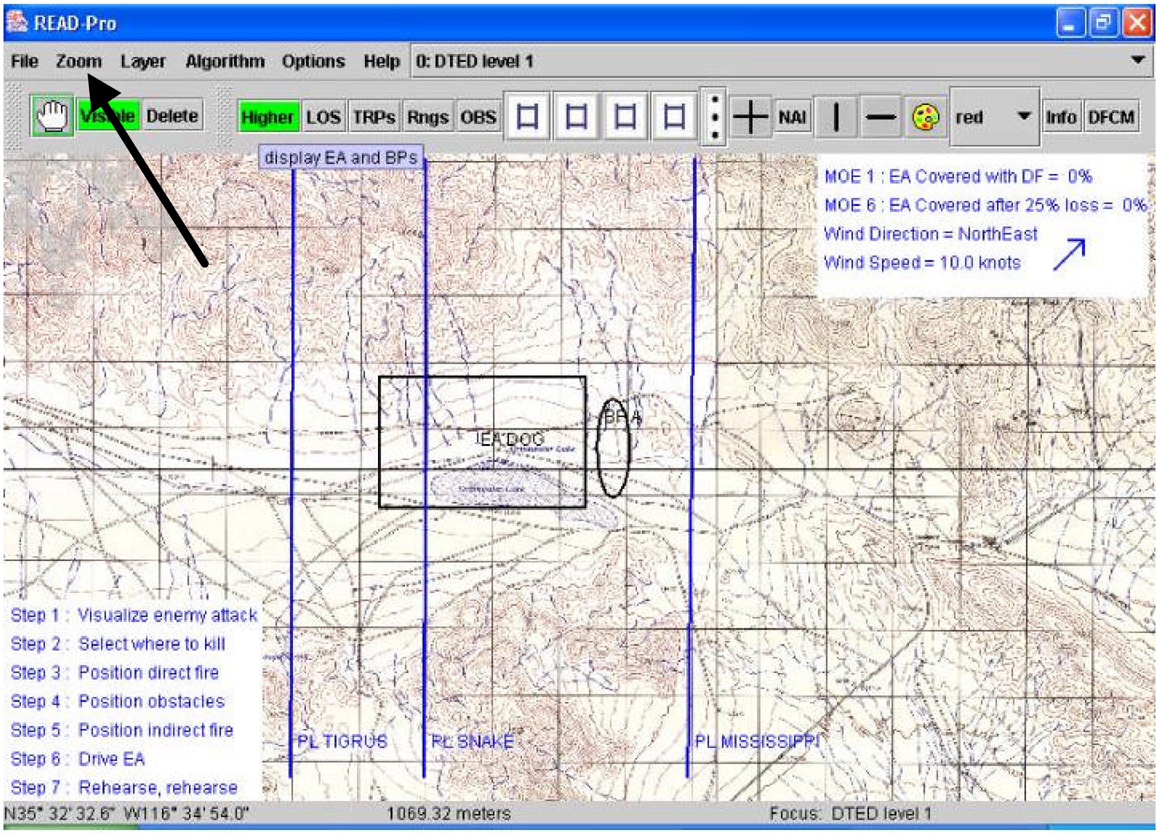



Figure 32. Zoom Level 1. There are 4 levels of zoom available to the user. The default screen is at 1:50,000 scale.

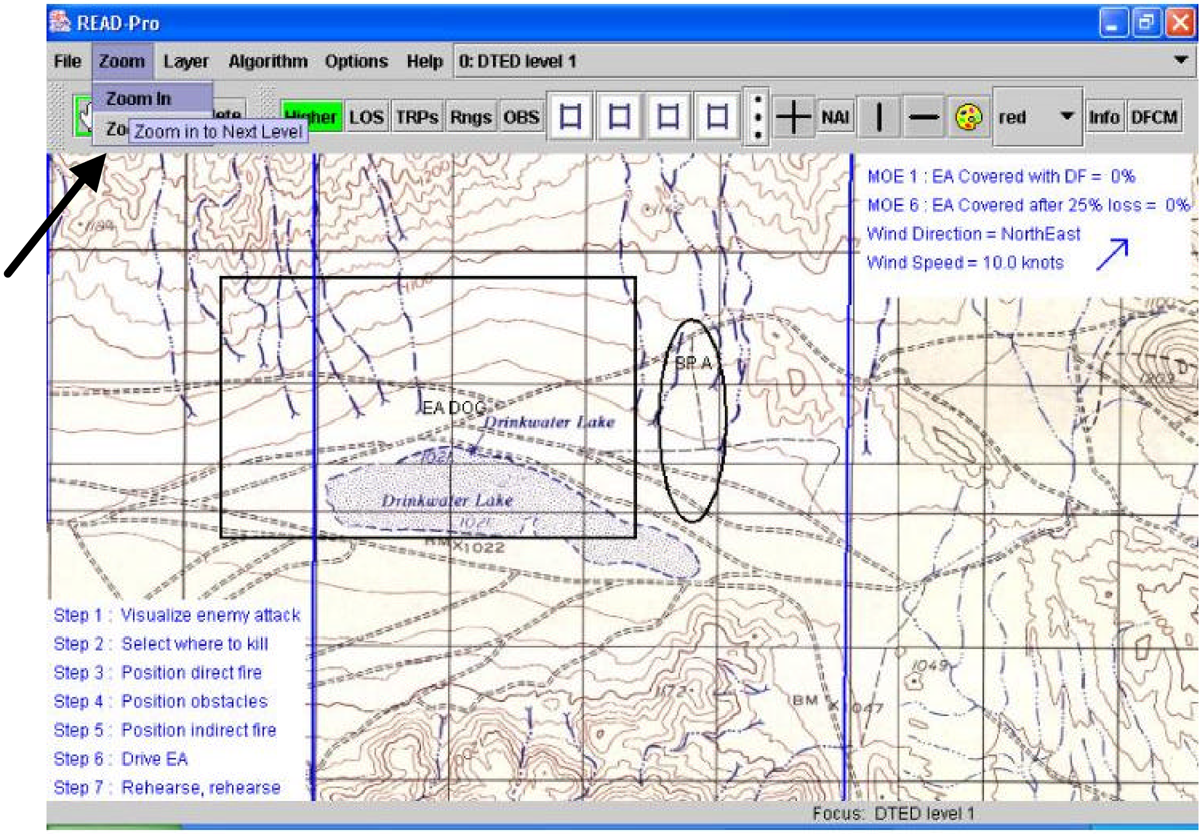



Figure 33. Zoom Level 2. Zoom at 1:25,000 scale.

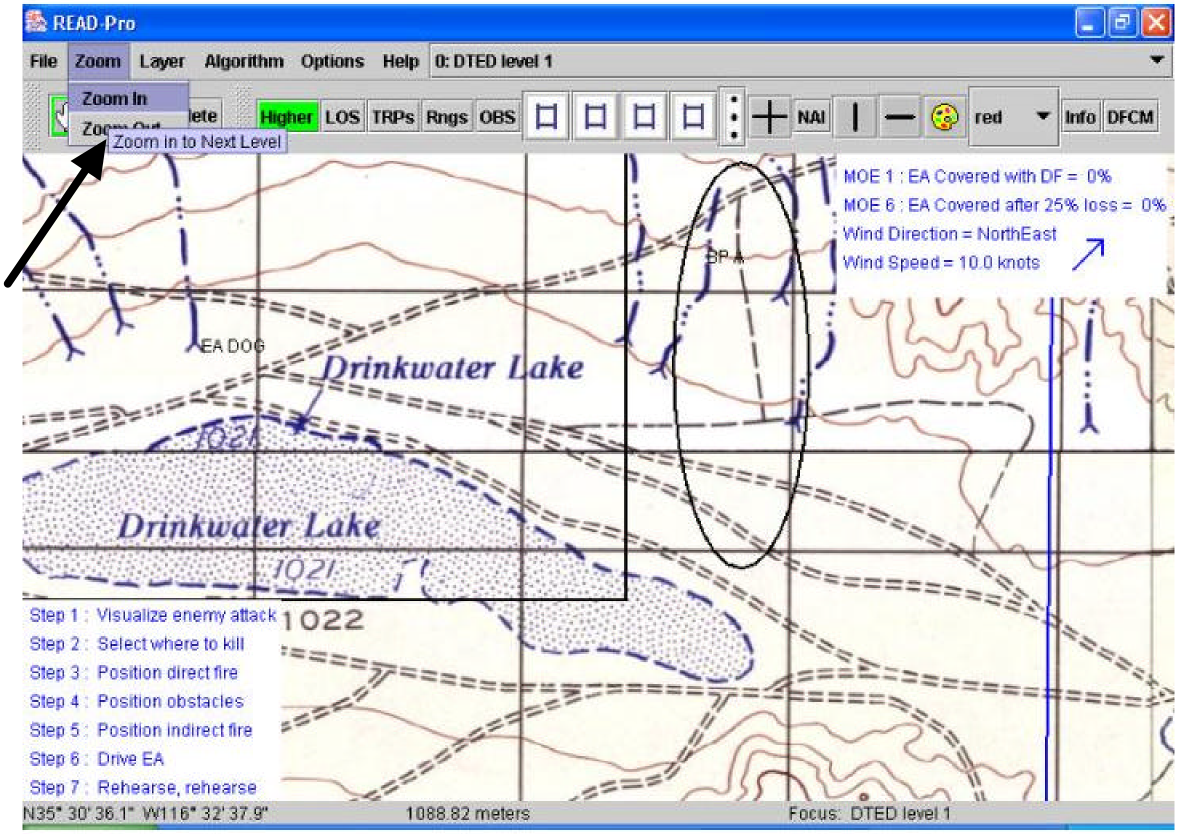



Figure 34. Zoom Level 3. Zoom at 1:12,500 scale.

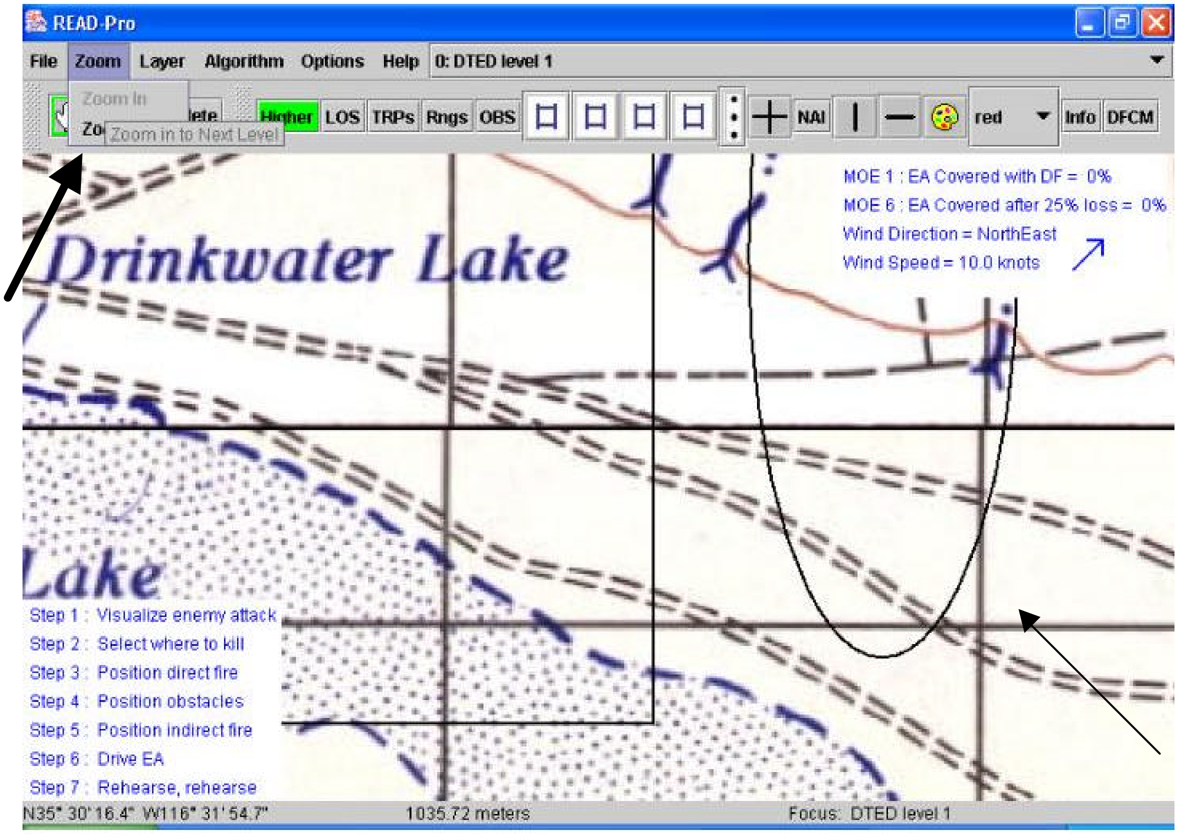



Figure 35. Zoom Level 4. Zoom at 1: 6,250 (greatest magnification)

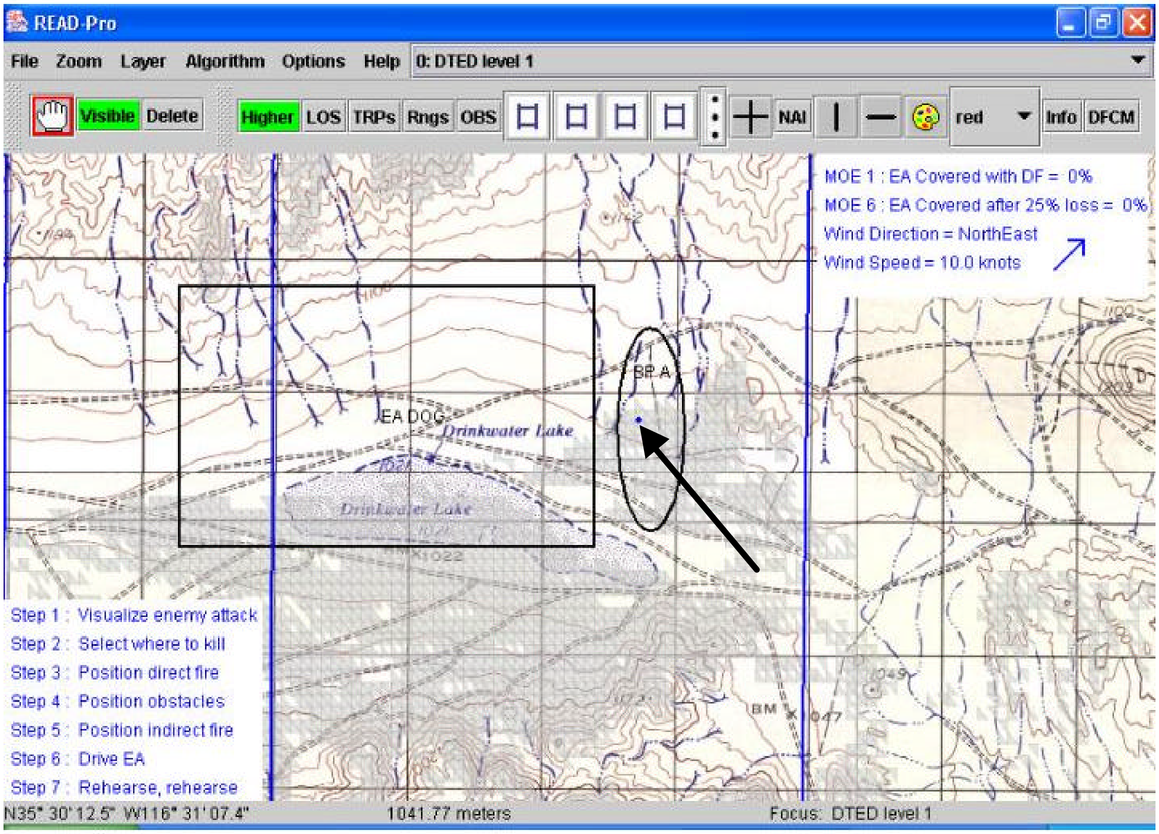



Figure 36. Line Of Sight. Double clicking a location (blue dot) with the mouse displays the line of sight for five kilometers in 360 degrees. Gray triangles show what can be seen from location of blue dot.

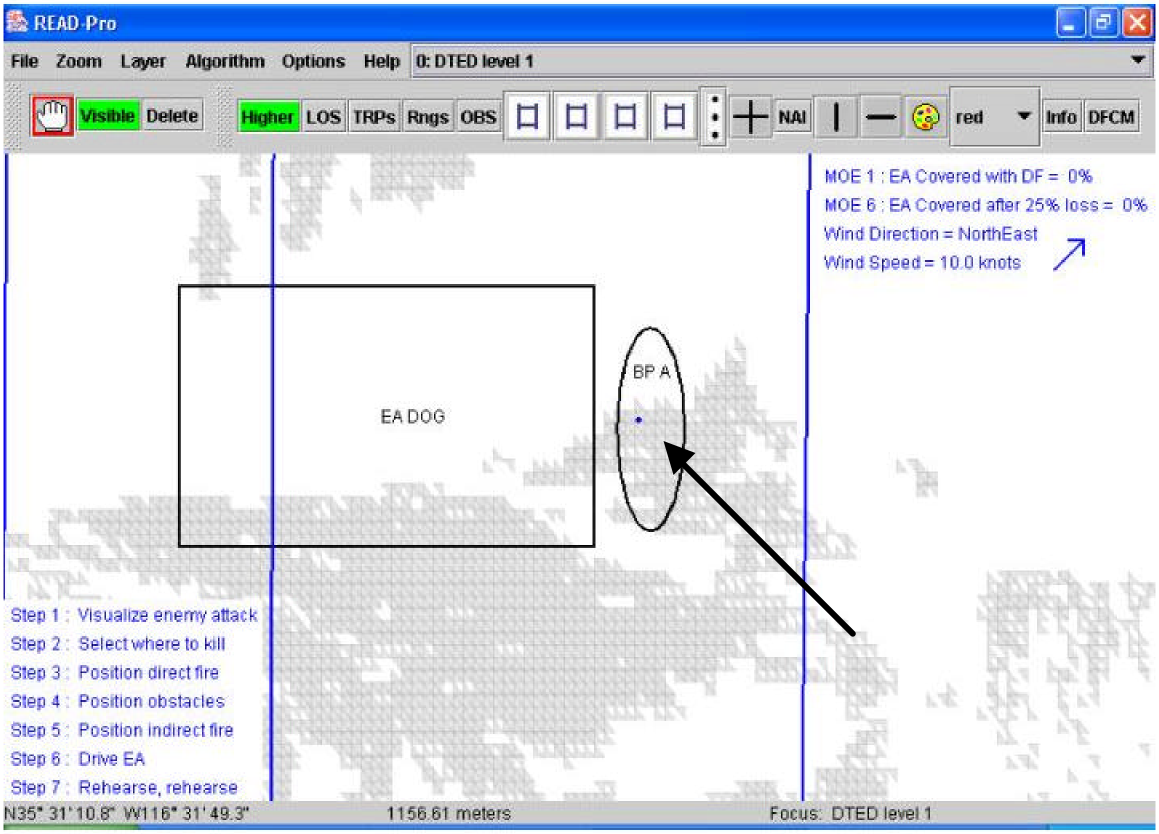



Figure 37. Line of Sight Display without Map.

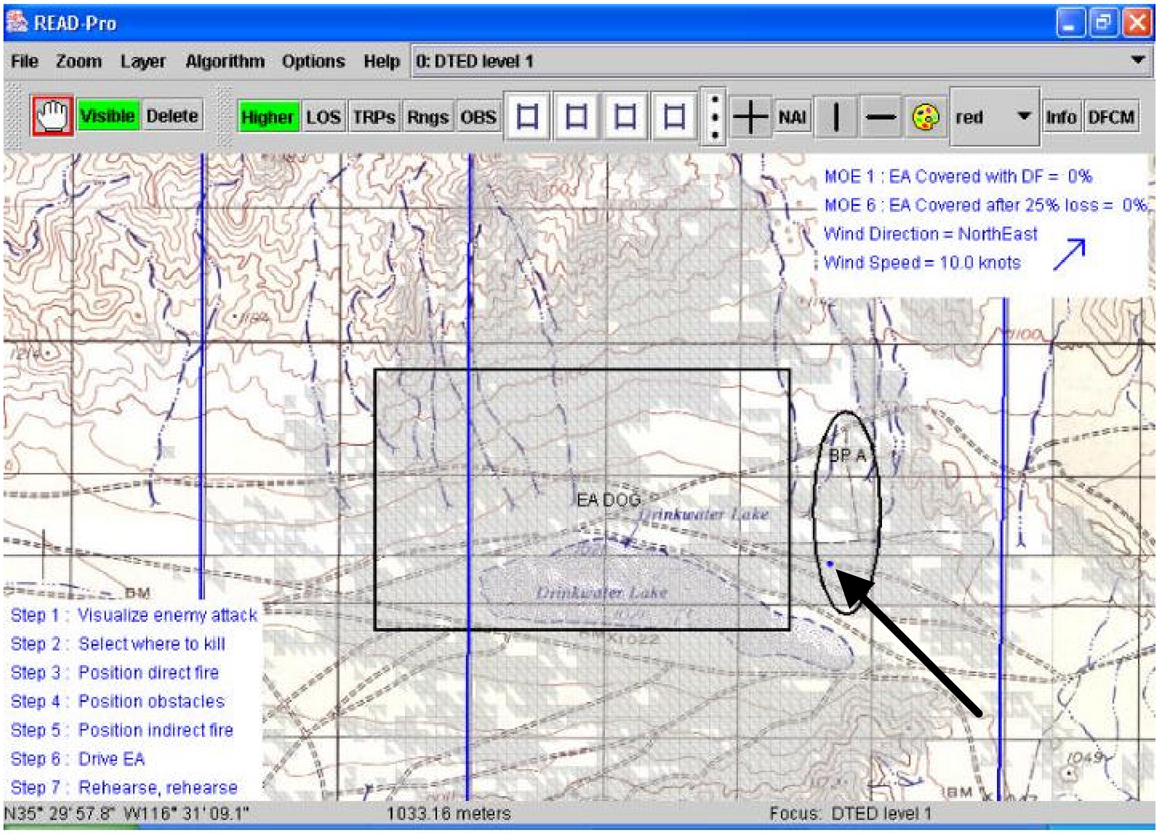



Figure 38. Line Of Sight From Different Location. Using the LOS feature, explore various locations until an adequate location is found to emplace a vehicle.

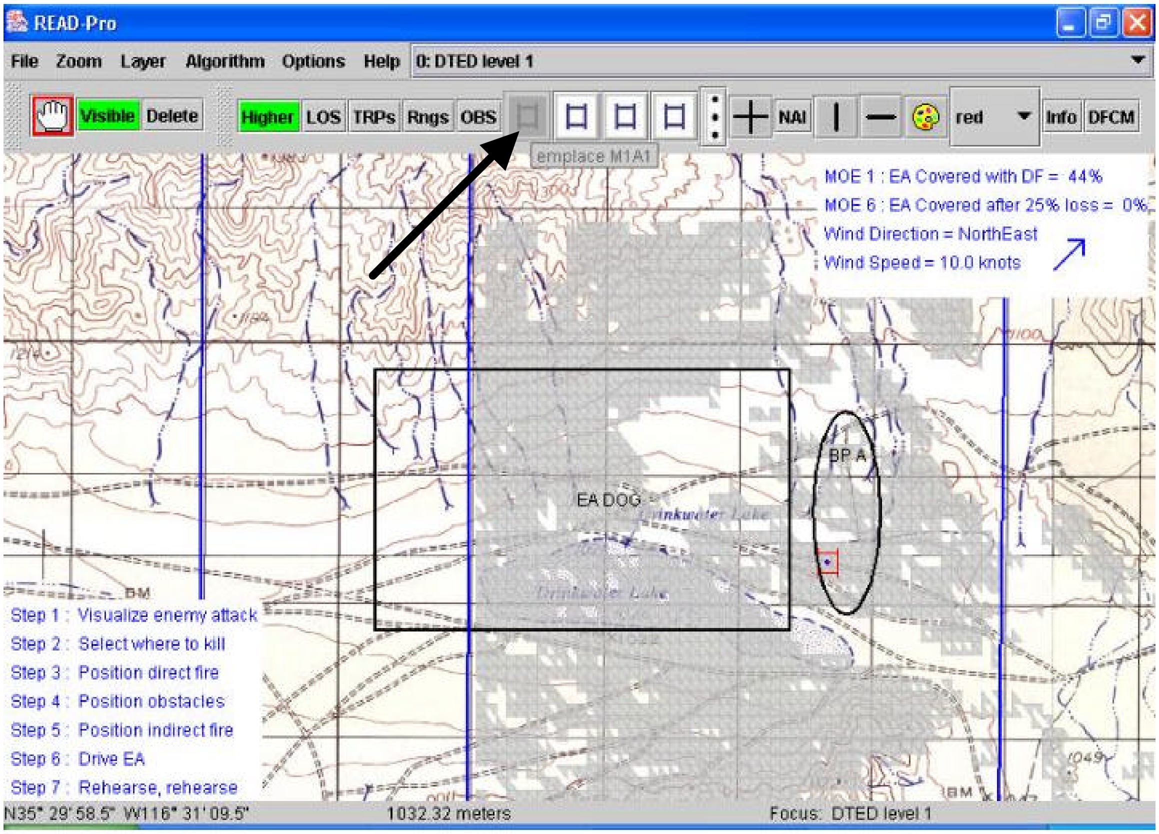



Figure 39. Emplace Platform. Select the platform you want to emplace, in this case a tank, and single click on the location on map. A grayed out button means the button is deactivated permanently. The tank appears in red (default color) on the map and displays the LOS out to its maximum effective range (2500 meters).

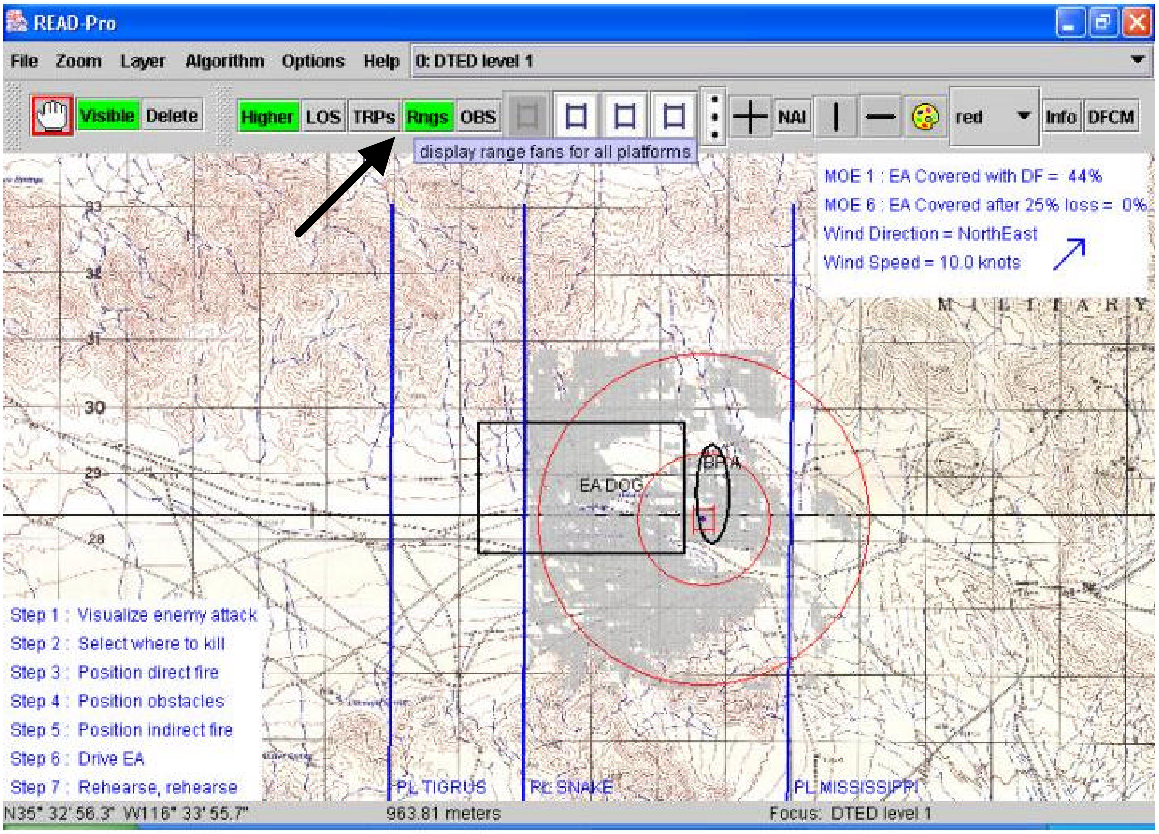



Figure 40. Range Circles. Toggle on range circle button to show the corresponding max effective range circles for the two main weapon systems of the given platform. Range circle lines are color coordinated to the color of the vehicle. For an M1A1 tank it is the machine gun at 1000 meters and main gun at 2500 meters.

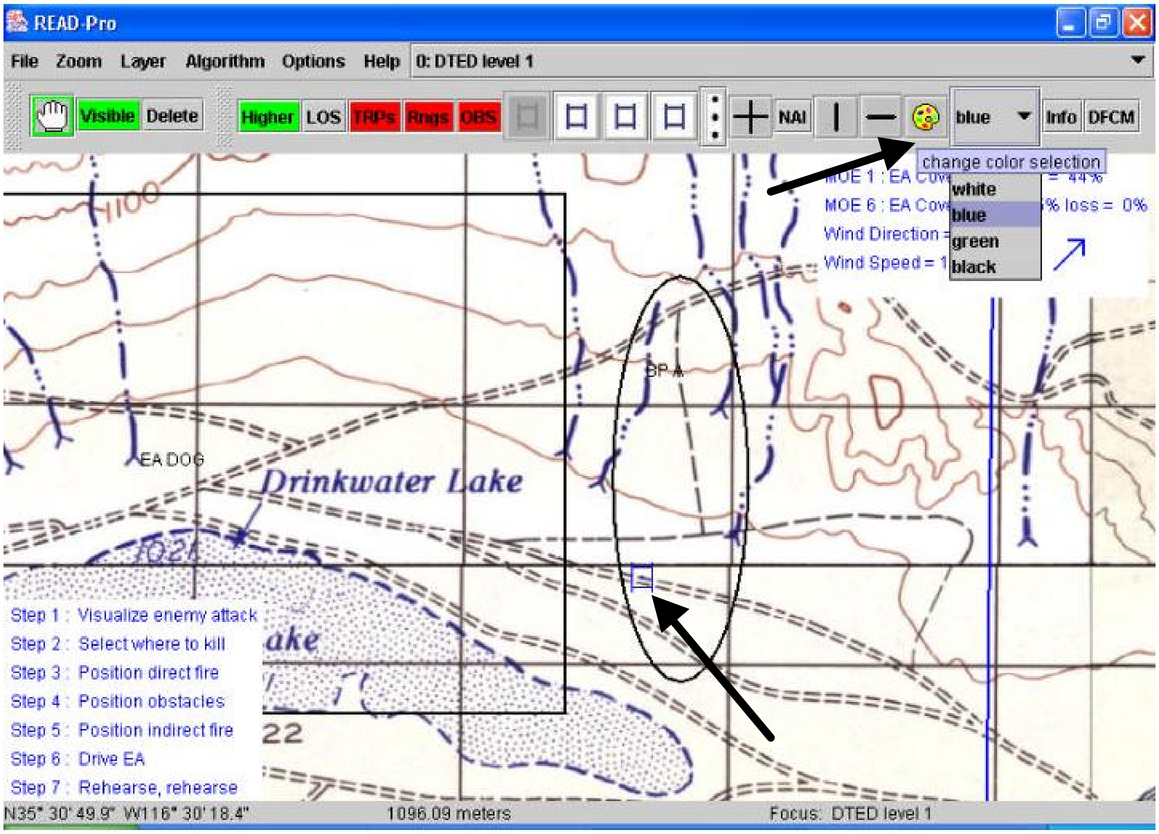



Figure 41. Change Platform Color. Change color of platform by first selecting color from drop down menu and then pressing the color pallet. Then single click in the center mass of desired platform. Tank was changed from Red to Blue.

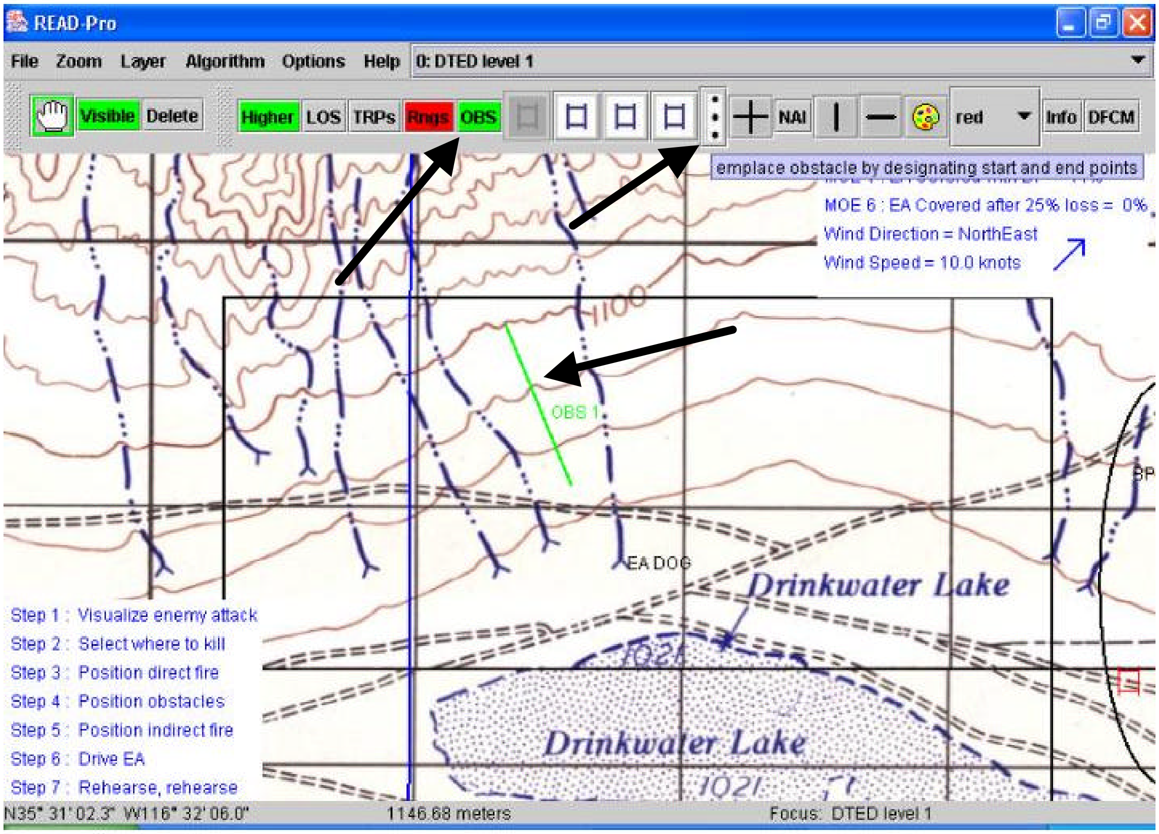



Figure 42. Emplace Obstacle. Emplace obstacle by selecting button that looks like a minefield and single clicking at the ends of the linear obstacle. Toggle the obstacle button on to see obstacles (shown in green).

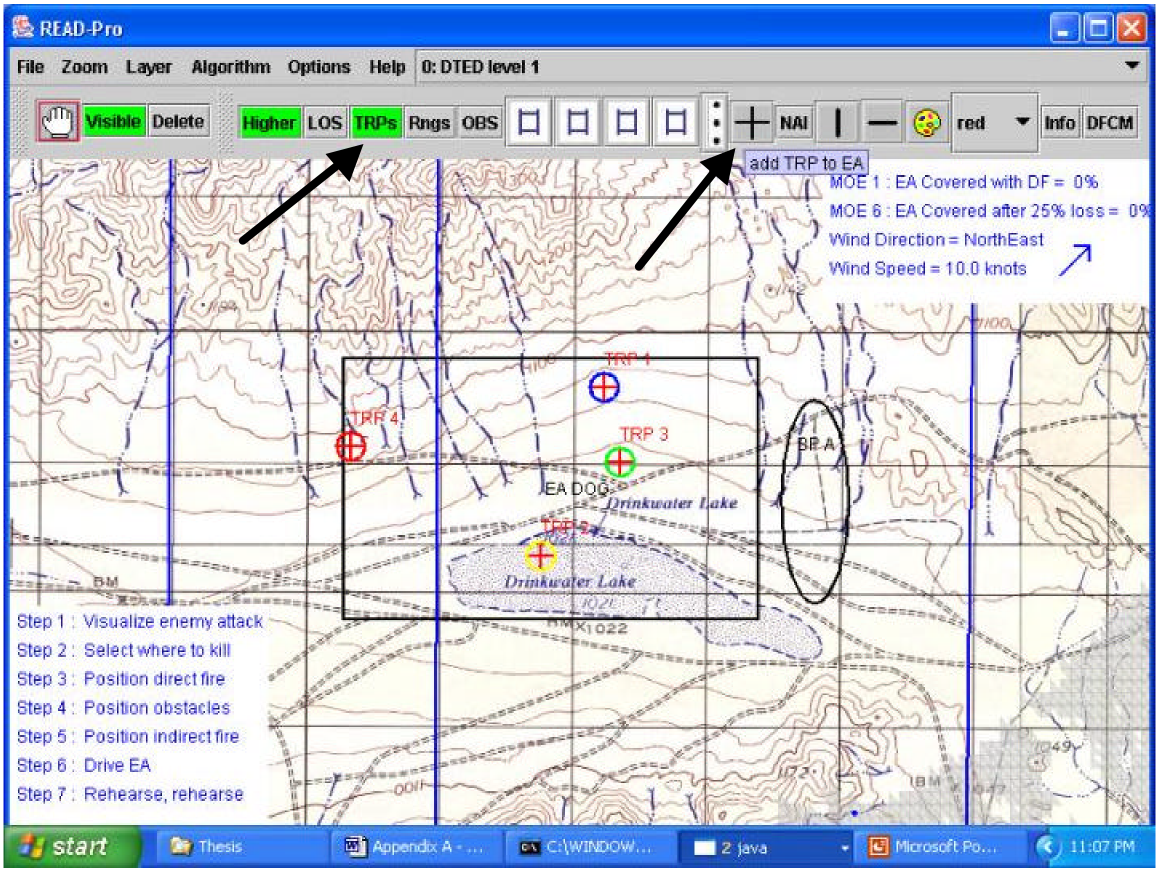



Figure 43. Emplace Target Reference Point. Emplace target reference points by selecting crosshair button and single clicking on location. Ensure TRP toggle is on in order to see TRP. Each TRP is color coded with a circle around the target according to the indirect fire units that can service the target. Green means both mortar and artillery units can reach target. Yellow means only artillery. Blue means only mortars. Red means no indirect fire weapon can reach target.

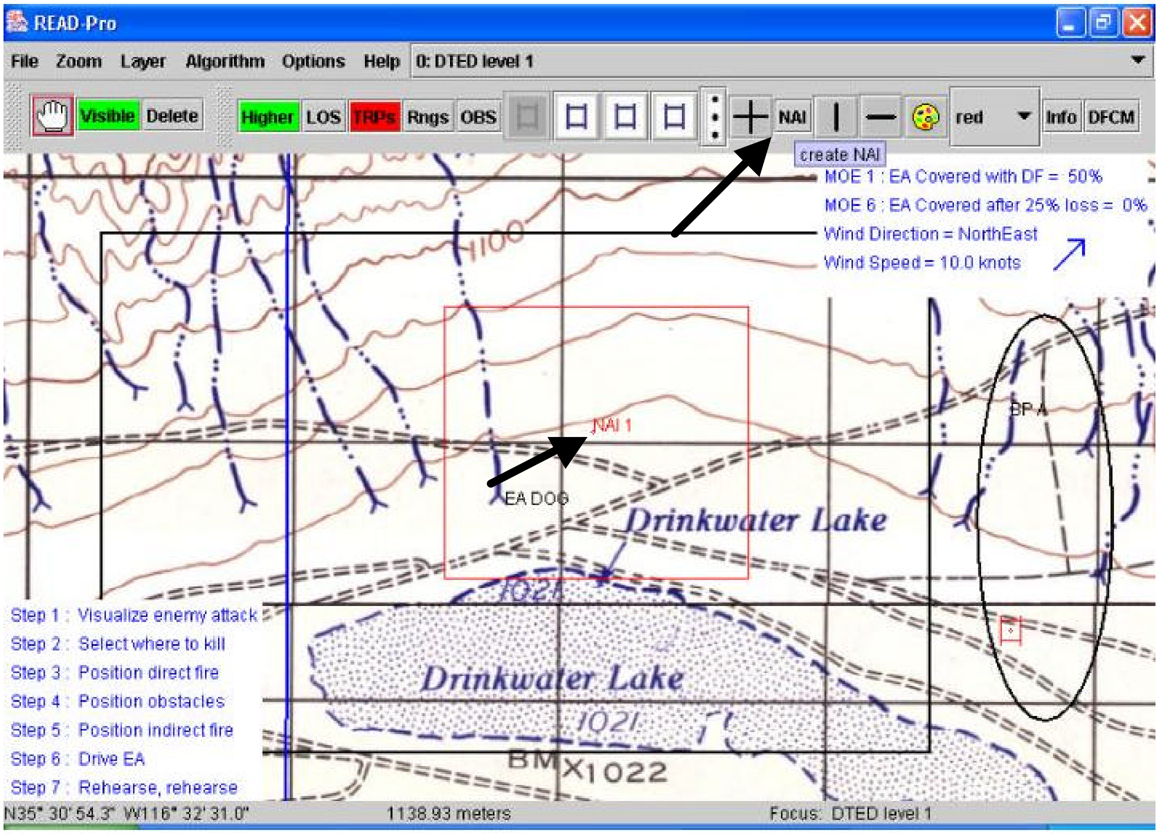



Figure 44. Emplace Named Area Of Interest. Emplace a named area of interest that is a 1000 X 1000 meter square.

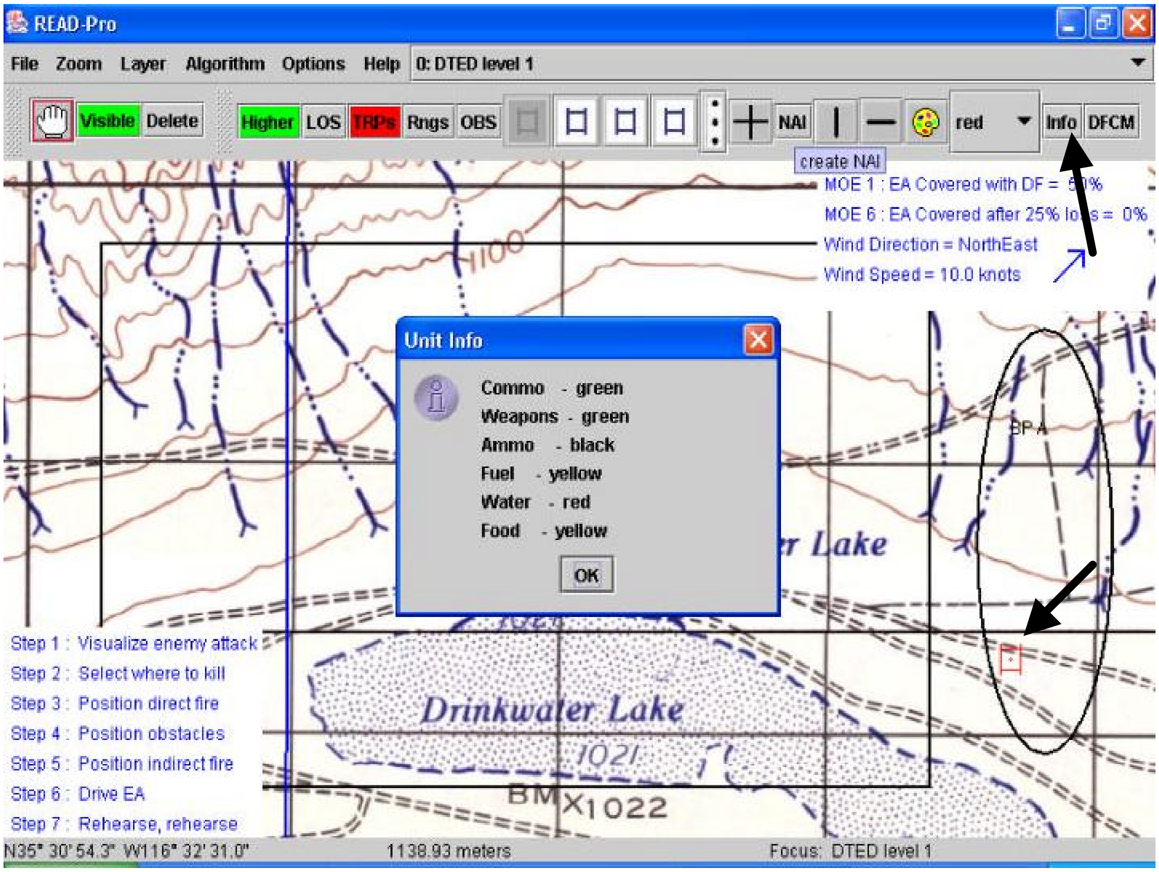



Figure 45. Unit Metrics. In order to display a platform's status for communications, weapon systems, ammunition, fuel, water, and food, select the 'Info' button and single click on a platform.

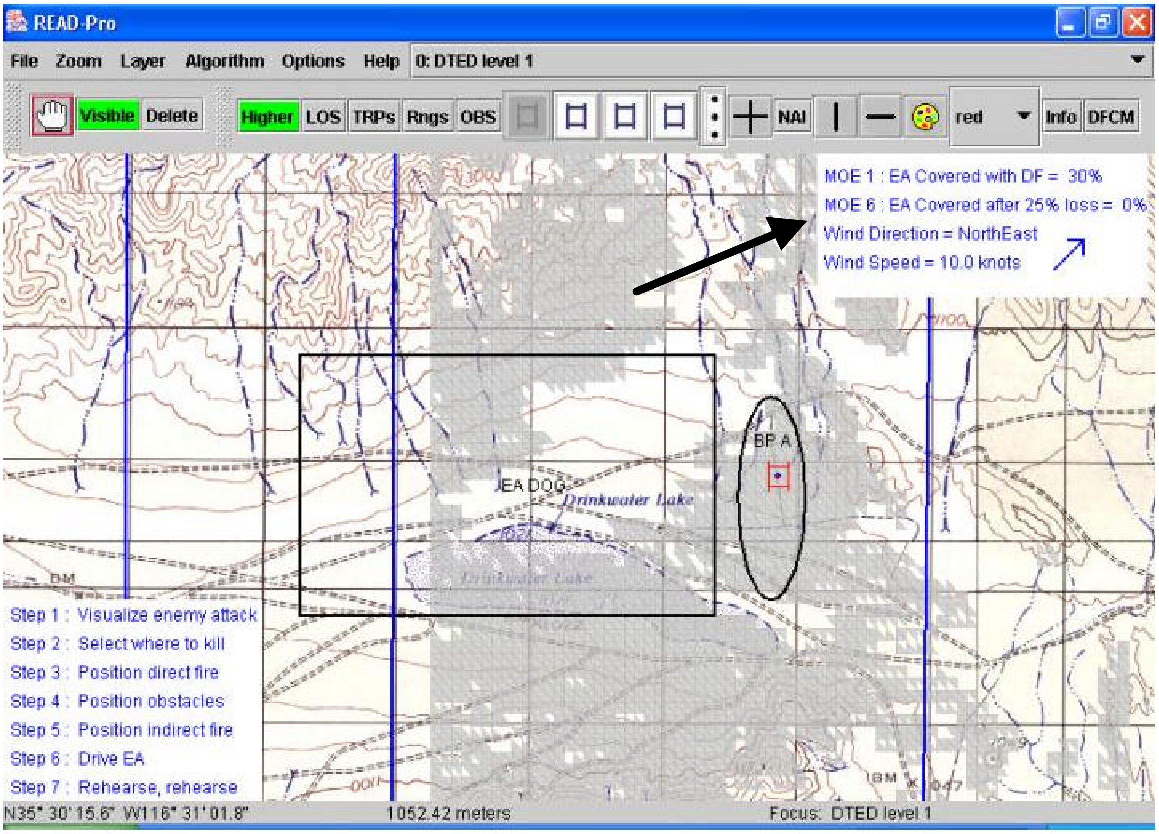



Figure 46. MOE 1 and MOE 6. One vehicle in BP A has an MOE 1 (percent of EA covered) equal to 30%. MOE 6 (percent of EA covered after 25% reduction in force) is equal to 0% because there is only one vehicle. Line of sight for Red vehicle shown.

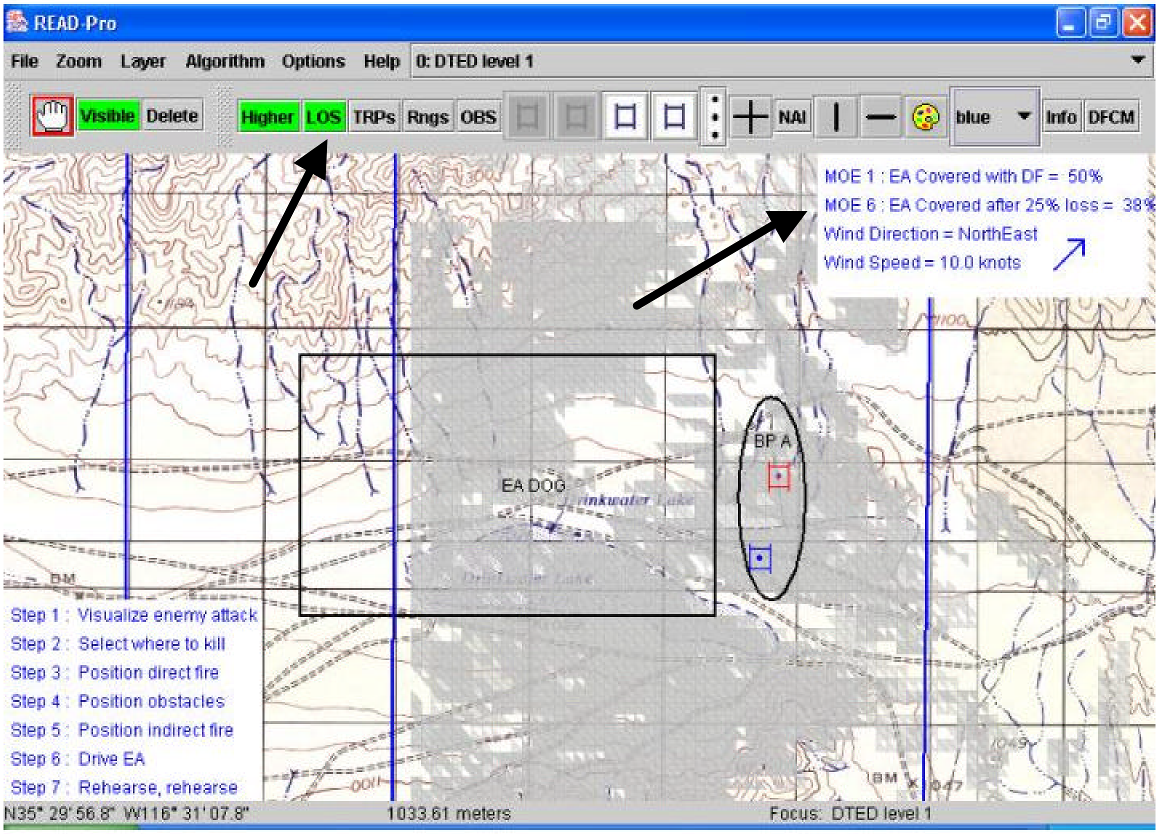



Figure 47. Both Vehicles in BP. Together, the Red vehicle (30% coverage of EA) and the Blue vehicle (48% coverage of EA), combine for an MOE 1 of 50% and MOE 6 of 30%. Line of sight for both vehicles shown.

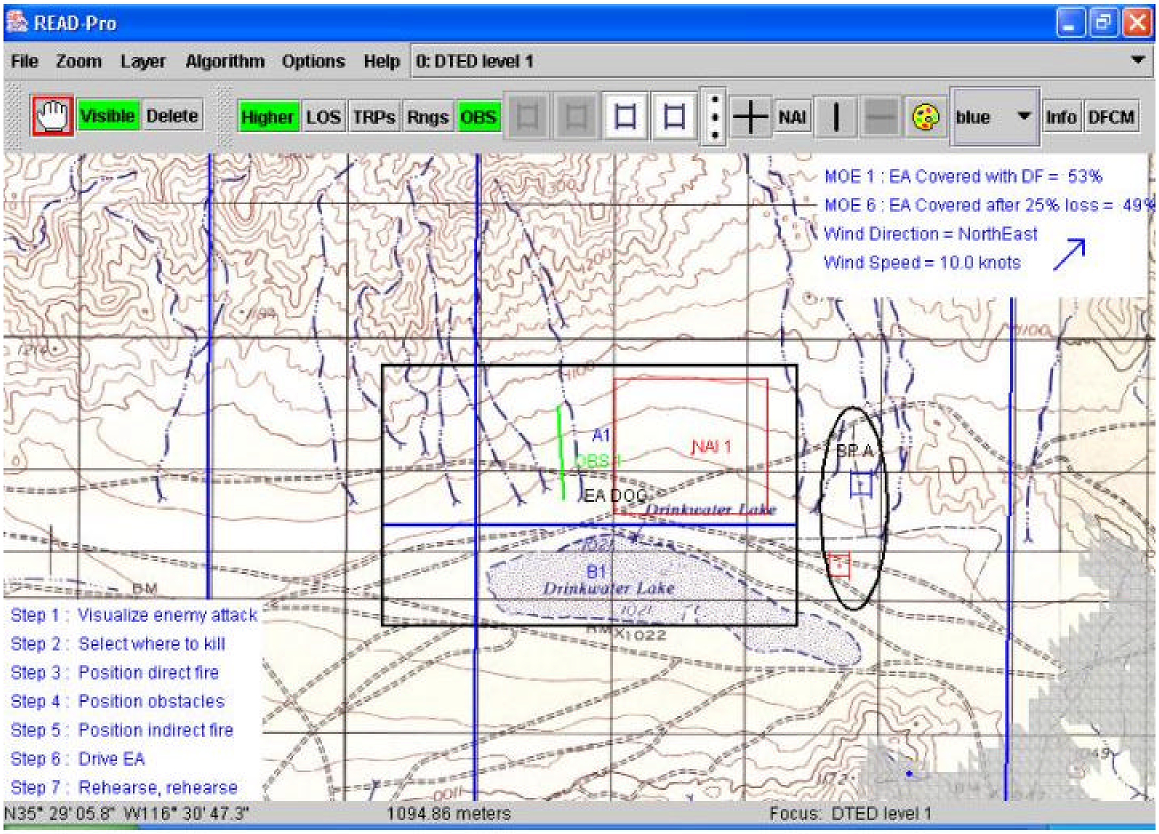
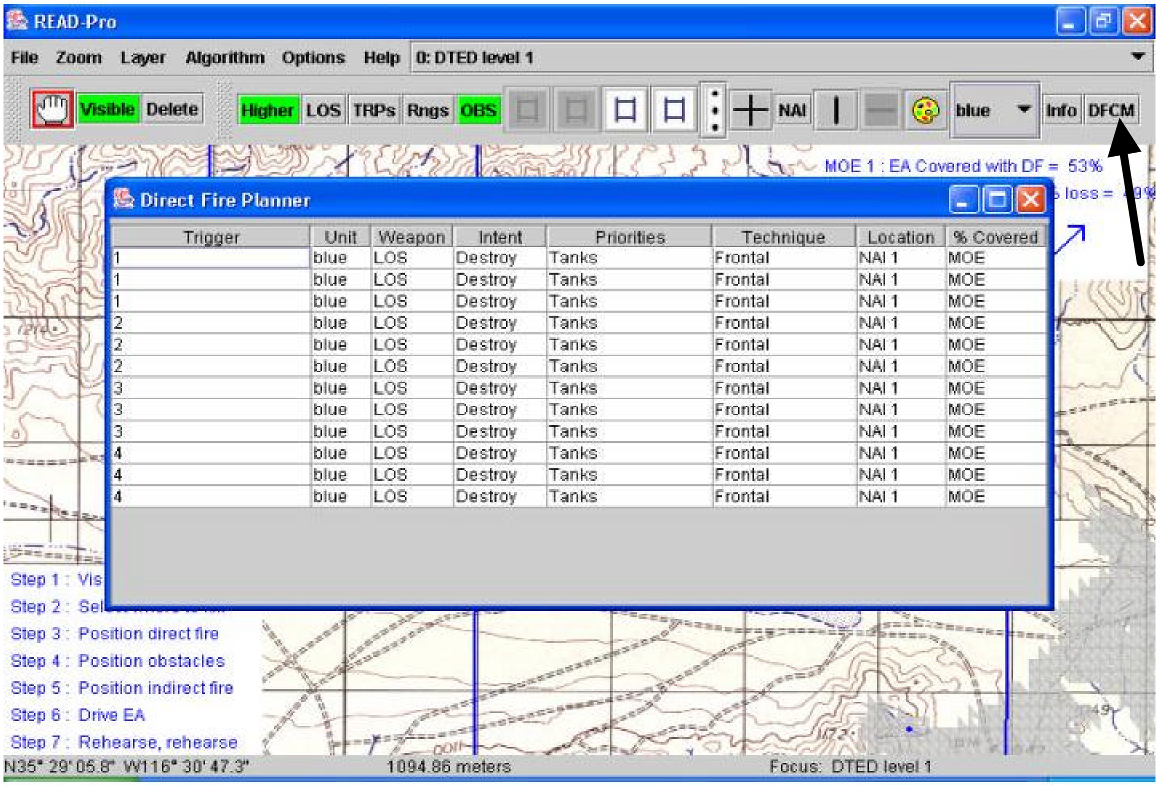



Figure 48. Items Imported into Direct Fire Control Matrix. The Direct Fire Control Matrix incorporates all objects emplaced by the commander. In this example there is a Red and Blue platoon consisting of one vehicle each, two EA quadrants A1 and B1,NAI 1, and OBS 1.




| Trigger | Unit | Weapon | Intent | Priorities | Technique | Location | % Covered |
|---|---|---|---|---|---|---|---|
| 1 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 1 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 1 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 2 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 2 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 2 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 3 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |
| 4 | blue | LOS | Destroy | Tanks | Frontal | NAI 1 | MOE |

Figure 49. Direct Fire Control Matrix. The DFCM button creates a default Direct Fire Control Matrix that displays the first choice from the drop down menus.


Figure 50. Drop down menus for DFCM. All platforms and area Objects (NAIs, obstacles, EAs, quadrants) are imported into the Direct Fire Control Matrix are available in the drop down menus for unit and location accordingly.

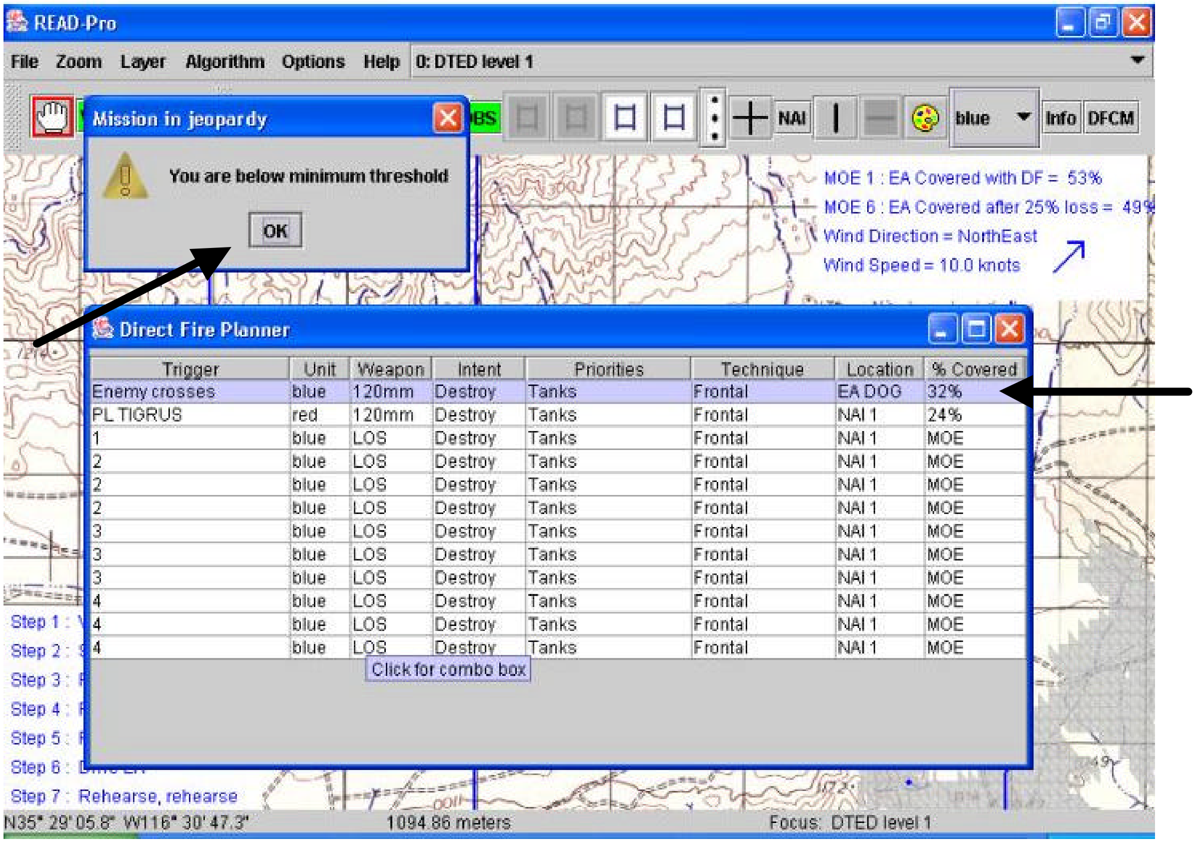



Figure 51. Percent Coverage in DFCM. Since Blue platoon only covers 32% of EA DOG, when the commander assigns this task, a warning window pops up informing the commander that the given unit covers less than 50% of the assigned area. The commander must acknowledge this by clicking ‘OK’ in order to continue.

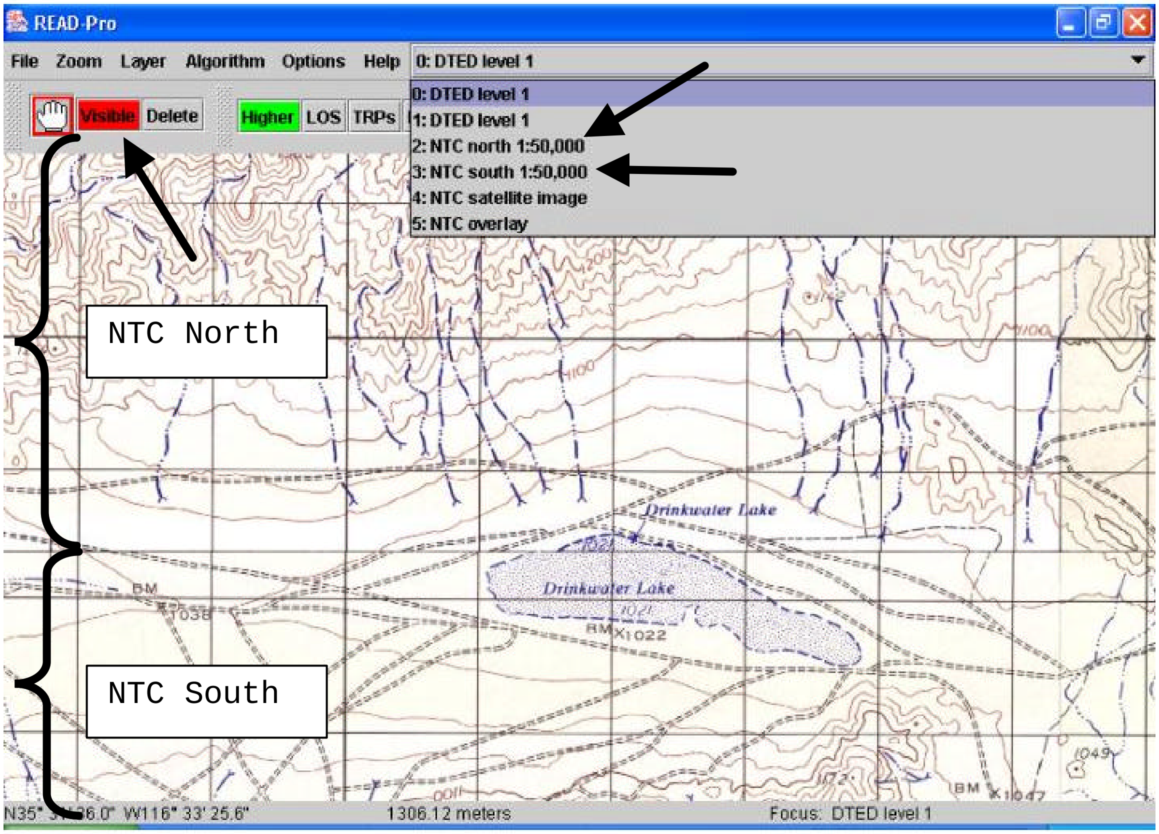



Figure 52. Drop Down Menu for Active Layers. Drop down menu lists all the layers currently available in READ-Pro. The selected layer can be manipulated with visible toggle and transparency adjustment. Each layer has its own toolbar and functions that pertain to only the selected layer. Current scenario is comprised of two map sheets, NTC North and NTC South, connected at the northern part of Drinkwater Lake.

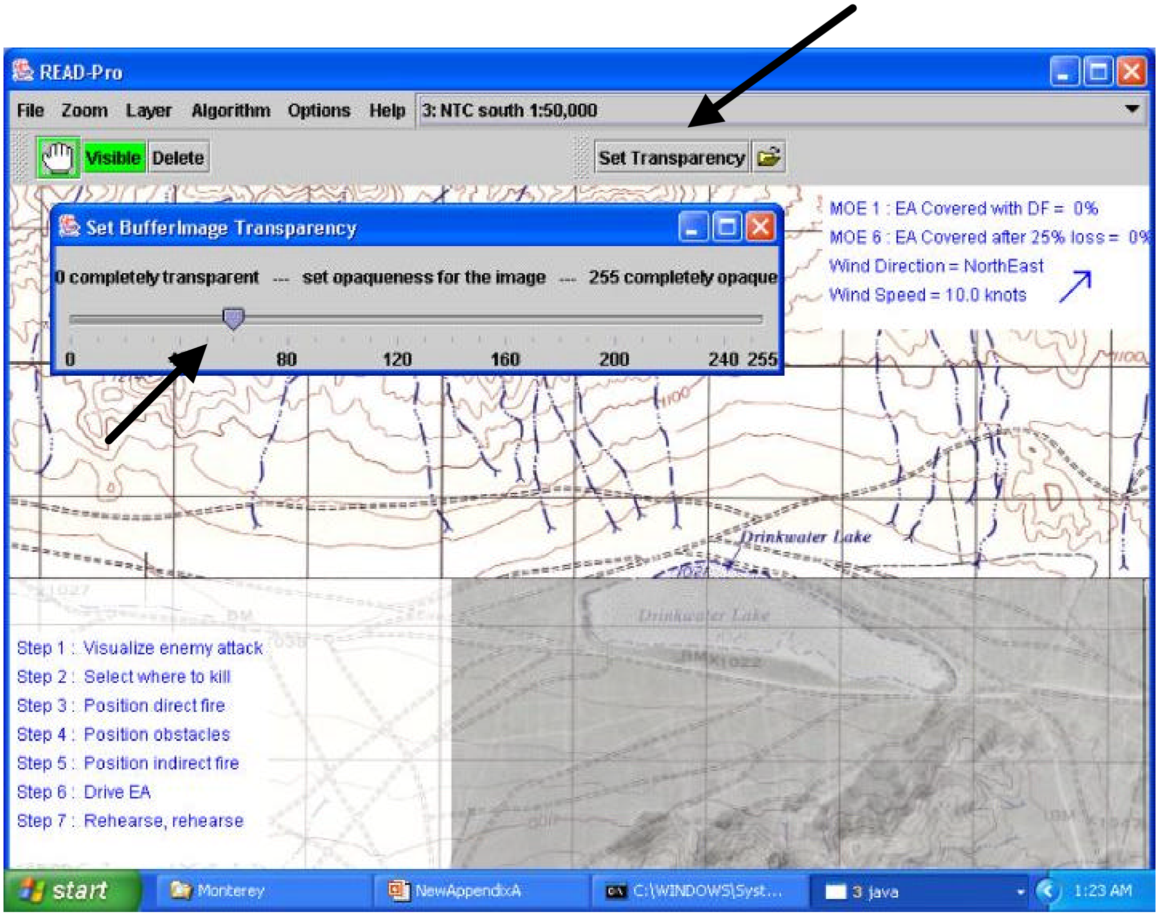



Figure 53. Transparency Function. NTC South is the selected layer and can be manipulated by the commander. By increasing the transparency of the NTC South map, the satellite image of the same area is revealed underneath. This is useful for integration of real-time imagery from satellites and Unmanned Aerial Vehicles.

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